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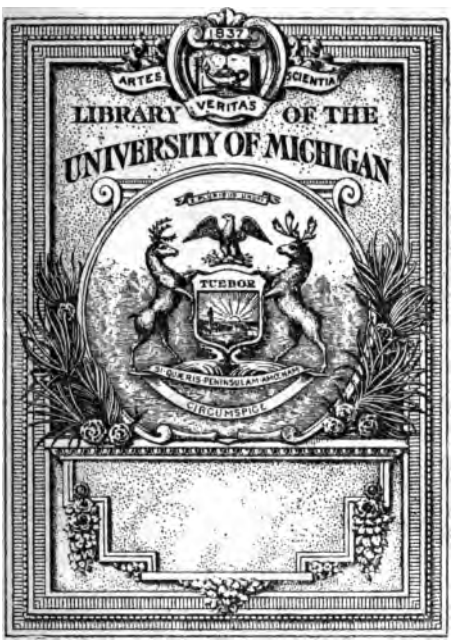
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MATHO:

OR, THE

Cosmotheoria Puerilis,

A

DIALOGUE.

IN WHICH

The first Principles of PHILOSOPHY and ASTRONOMY are accommodated to the Capacity of young Persons, or such as have yet no Tincture of these SCIENCES. Hence the Principles of Natural Religion are deduced.

Translated, and enlarged by the AUTHOR.

Andrew Baxter, 1686? – 1750.

VOL. II.

Nam corpus hoc animi pondus & poena est: Premente illo urgetur, in vinculis est, nisi accessit Philosophia, et illum respirare rerum naturæ spectaculo jussit.——Vetas me cœlo interesse, id est, jubes me vivere capite demisso. Seneca.

LONDON:

Printed for A. MILLAR, at *Buchanan's-Head*, over-against St. *Clement's* Church in the *Strand*; and Sold by him, and J. HODGES on *London-Bridge*. 1740.

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The Seventh CONFERENCE.

Matho *and* Philon *reſume the Diſcourſe concerning the Planetary Syſtem. Of the compound motion of the Satellites round their Primary Planets, and with their* Primaries *round the Sun. A Body, that it may revolve about a Center, (which Center itſelf revolves about another Center) muſt indefinently be urged by four different Forces; two with reſpect to each Center. That each of theſe Forces is conſtantly impreſſed (or at leaſt ſucceſſively renewed) by an* immaterial Power, *and not owing to one original Impulſe. Of that* Limit *between the Sun and any Primary Planet, where their attractive Forces are equal. That any Secondary Planet muſt revolve within that Limit: or, the Orbit of the* Secondary *muſt lie between that Limit and its Primary.* Page 1, 2

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The Eighth CONFERENCE.

Matho *deſires to know why the Secondary Planets might not have revolved ſeparately about the Sun, as the immediate Center of their Motion? If the Diſtance of the Satellites from their Primaries had been greater or leſs, what muſt the Conſequences have been? That there may be more Bodies in the Solar Syſtem than are diſcoverable by us. In what Proportion the centripetal Force is increaſed or diminiſhed, as the Planet is nearer to, or more remote from the Sun. From what Cauſes the centrifugal Force becomes greater or leſs. It is ſhewn neceſſary, by bringing the centripetal and centrifugal Forces to an Equilibrium, that the Cubes of the Diſtances of the Planets from the Sun muſt be as the Squares of their Periodical Times. And contrarily, as this Proportion holds in fact, from thence it is ſhewn, that the centrifugal, and therefore the centripetal, Force muſt be inverſely as the Squares of the Planets Diſtances from the Sun.* p. 65,66

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The Ninth CONFERENCE.

What muſt have been the Conſequences if the Moon had moved in a Plane croſſing the Ecliptick, or Plane of the Earth's Orbit, at right Angles. That our Earth is a Moon to its own Satellite, appearing to her near 16 *Times larger than the Sun himſelf, and thereby throwing on her a vaſt Gleam of Light.* Jupiter *appears to the innermoſt of his Satellites* 1600 *Times larger than the Sun does to us; and* Saturn *more than a* 1000 *Times larger to his neareſt Satellites: They muſt therefore throw a prodigious Splendor on their own Moons. That the Planets both Primary and Secondary are thus carefully illuminated, ſhews they are not empty Seats; but deſigned for Habitation: For* Light, *in the Nature of Things, anſwers to* Eyes. *A ſkilful Artiſt could not deſign that which is more noble for the Uſe of what is of an inferior Nature. The whole material Univerſe was therefore made for the Sake of Rational Beings. That our Sun at the Diſtance of* Sirius *or* Arcturus

Arcturus *would appear but like one of the fixed Stars, and the ſolar Planets be quite abſorbed by the immenſe intervening Space. The great centrifugal Force on the larger Planets a Relief to their Inhabitants, as ſuſpending a conſiderable Part of their Weight on thoſe vaſt Bodies. The Denſity of thoſe great Bodies wiſely contrived in being leſs than in ſmaller Bodies, upon this Account. An eaſy Way to calculate their Quantities of Matter and Denſities.*

The Tenth CONFERENCE.

As the Weight of Bodies on the leſſer Planets is but ſmall, their Rotation on their Axes is ſlow, and their centrifugal Force but weak. Heat and Light are diſpenſed rather according to the Surface, than the Quantity of Matter in the luminous Body; hence the Sun is but of a moderate Denſity. That the outermoſt and innermoſt of the Planets are not uninhabitable by Reaſon of the Extremities of Heat or Cold. Heat is not always in Proportion to our Vicinity to the Sun: Cold requires a poſitive Cauſe, or ſomething more than the mere

mere Abſence of Heat. The Extremities of both may be qualified by the Conſtitution of an Atmoſphere. That all the Planets are ſurrounded with Atmoſpheres. The phyſical Explication how Bodies may deſcribe elliptical Orbits about an attracting Body, placed either in the Center of the Ellipſis, or in one of its Foci; according as the Law of Attraction is ſuppoſed different. Theſe two Caſes compared between themſelves, and the Tranſitions from the one to the other ſhewn natural and eaſy. The Proportion between the Squares of the periodical Times and Cubes of the middle Diſtances, ſtill obſerved when Bodies revolve in Ellipſes. The Comets revolve by the ſame Laws, and obſerve the ſame Proportions as the Planets.——Of the Immortality of the Soul. That the Soul is not aſſiſted to think and perceive by Organs of a dead Subſtance; but is by theſe confined and limited to a particular Manner of Action and Perception. Whether the Deity could cut off rational Beings, for whoſe ſake the material World was created; the Frame itſelf ſtill remaining. The Deſire of Exiſtence the Foundation of all our other Deſires, and the Source of all great

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Nor are the other things you mention leſs, but rather more difficult.

M. I am aware of the Difficulty of the firſt Particular; But this whets my Curioſity the more.

P. To give you what Aſſiſtance I can then: With reſpect to the Motion of the Secondary Planets round their Primaries, you ſaw before, or rather found out from Arguments of your own, That the celeſtial Bodies have their globular Figure from the mutual Attraction between all their Parts; and that this Attraction does not ceaſe at their Surfaces, but prevails through a certain ſpherical Space round them, according to the Quantity of Matter each of them contains. Hence comes the *Relative upward* and *downward* belonging to every particular Planet in our Syſtem; from which Relation this Attraction is called Gravitation; for Gravitation is only a relative Term. And from this *particular Attraction* it is, that the Satellites roll round their Primary Planets, the ſame Way, and by the ſame Laws, as the Primary Planets do round the Sun: Therefore where there are more Satellites than one, the Squares of their periodical Times, about the great Planet, are as the Cubes of their Diſtances

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Diſtances from it; juſt as it is with reſpect to the Times of the Primary Planets about the Sun, and their Diſtances from him.

XCIII. *M.* This I remember, and ſee plainly enough that their circular Motion muſt be cauſed by a gravitating and projectile Force conſtantly acting upon them: This holds univerſally in all Bodies revolving about a center in free Spaces. But then, how do you combine with this Motion that other, whereby they are carried along with their *Primaries* round the Sun? Or is the Attraction of their *Primaries* ſtrong enough to carry them thus along through their own larger Orbits, without any other Force impreſſed?

P. By no means. —— But to help your Imagination in this Affair, ſuppoſe at firſt that the Sun is quite abſent, and that the *Primary* remains as an immoveable central Body inſtead of the Sun.

M. What then?

P. In this Caſe, the gravitating and projectile Forces being impreſſed on the Satellite, you ſee it muſt revolve about its *Primary* (now ſtanding ſtill) juſt as the Primary it ſelf revolved about the Sun before.

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M. The ſame way indeed; for there is no Difference between the two Caſes.

P. Imagine then that the *Primary* is impelled ſtraight forward, together with its *Satellite*; a Force being impreſſed on both by *ſome ſkilful* and *mighty Hand*, always in parallel Directions; while in the mean time the two former Forces (namely, the *gravitating* and *projectile*) act conſtantly on the Satellite, as before this laſt Force was impreſſed: And conſider then what will be the Reſult.

M. The *Satellite* is now urged by three Forces: *This laſt* carries it foreward in a parallel Direction with its Primary; and by the *two firſt* it muſt ſtill roll round its Primary, I ſuppoſe, as if neither *that* nor itſelf were impelled forward. But there is ſomething here which I do not fully conceive.

P. Leave particular Niceties 'till another time, and endeavour at firſt only to get a general Notion of the Caſe. In the main it is as you ſay: For we may be ſure that no one of the *three Forces* impreſſed can be without its Effect, more than if they had been impreſſed ſeparately on three different Bodies. Now keeping theſe things in your Mind, imagine the Sun to be brought back to his

Place again; and then consider what will ensue. Seventh Conference.

M. The Sun being replaced, Gravitation towards him must begin to act on both the *Primary* and *Secondary*; and the excursory or projectile Force (by which, to wit, both were impelled straight forward in parallel Directions) was impressed on both before. Whence, since they are, by Supposition, at a due Distance from the Sun; so that neither his Attraction nor their excursory Tendency can overcome the one the other; they must begin, I think, to roll round him; while in the Interim the Satellite continues to perform its lesser Rotations about its Primary, as before.

P. You trace out the Consequences very distinctly; and from this you will be able to form a Notion, how such a complex Motion of the Satellite is effected.

M. I conceive it indeed in some measure: But as there are four different Forces constantly impressed here on the Satellite; tho' I easily apprehend how it should be attracted to two different Centers; yet I can hardly reconcile in my own Mind the two different projectile Forces impressed on it; one with respect to its revolving about its own *Prima-*

ry,

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ry, and the other with reſpect to its revolving along with *that* about the Sun; which muſt ſo often interfere and oppoſe each other. Pray might we not ſuppoſe that the larger Planet, while it moves on in its own Orbit, attracts the Satellite or leſſer Planet, ſo ſtrongly, as to carry it along without any other Force impreſſed upon it?

P. By no means, I ſay: We muſt not make Suppoſitions contrary to the Reality of Things. If we take our *Earth* and *Moon* as an Example, we ſhall find *that Suppoſition* inconſiſtent with the Nature of the Moon's compound Motion: Nor is there any way of getting free from the conſtant Impreſſion of theſe four different Forces (and therefore of the two different projectile Forces) upon her at once.

M. Then I ſee the Truth of what you ſaid, That the compound Motion of the Satellites is harder to be conceived than any thing I have hitherto met with. But how does this conſtant Impreſſion of two different projectile Forces appear from the Example of the *Earth* and Moon?

P. We obſerved before, if the Diſtance of the Earth from the Sun be 21000 of its own Semi-diameters, its Motion in its annual Orbit

Orbit muſt be at the rate of 1000 Miles in a Minute: And it is certain that the attractive Force of the Earth upon the Moon could only draw her a little more than 16 Feet in a Minute. Now when the Moon is in her laſt quarter, that is, directly behind the Earth in its annual Orbit, ſhe is not left behind the Earth, but moves with equal Velocity, or after the rate of 1000 Miles in a Minute; and yet could only move in the ſame Direction ſo ſmall a Space as 16 Feet by the attractive Force of her Primary Planet. Seventh Conference.

M. This is an enormous Difference!

P. It is indeed; and though we ſhould ſuppoſe the Diſtance of the Earth from the Sun leſs, and therefore its Velocity leſs; the Difference would ſtill be enormous. —— In advancing from this Point of her Orbit to her Conjunction with the Sun, ſhe is there as far forward with reſpect to the annual Courſe of the Earth, as the Earth itſelf is.

M. I underſtand; for ſhe is now got between the Earth and the Sun.

P. Therefore in about ſeven Days Time, beſides moving at the rate of 1000 Miles every Minute, ſhe hath gained upon the Earth nearly 240000 Miles, or the whole Semi-diameter of her own Orbit.

M. It

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M. It is ſo.

P. But this is the Effect of a different projectile Force; in her own Orbit, to wit: For the Attraction of the Earth could not have brought her ſo far forward. This Attraction (as has been ſaid) could only have drawn her 16 Feet in any Minute, and that toward the Center of the Earth: Whereas here (conſidering her Motion as parallel to the Earth's) ſhe hath moved about 22 Miles in a Minute, over and above the 1000. For 240000 Miles in 7 Days 9 Hours comes much to this.

M. Go on. This is plain.

P. In moving on to the firſt Quarter after the Conjunction, ſhe is now got directly before the Earth in its annual Courſe, as about 14 or 15 Days before ſhe was behind it: Therefore ſhe has gained on the Earth another 240000 Miles. And in this Part of her Orbit ſhe moves on in the annual Courſe 1000 Miles in a Minute, directly contrary to the Earth's Attraction.

M. I ſee it clearly.

P. In aſcending to her Oppoſition with the Sun, when ſhe appears full, ſhe hath loſt 240000 Miles, with reſpect to the Velocity of the Earth's Motion; or the Earth is as far

far advanced in the annual Courſe as ſhe: And in returning to the firſt Point again, that is to her laſt Quarter, ſhe hath loſt 240000 Miles more: The Reaſon of which is eaſily ſeen. In all theſe Caſes, her rapid Motion in attending the Earth, you find, is not in the leaſt affected by her Gravitation towards it. That does no more than balance her centrifugal Force in her own Orbit.

XCIV. *M.* You have now fully convinced me of the Neceſſity of impreſſing both theſe projectile Forces on the ſecondary Planet, eſpecially the *firſt*, with reſpect to its Motion about the Sun, always in a parallel Direction to the Motion of its Primary; and at the ſame Time you have raiſed in me an Admiration of a Motion ſo complex, and ſkilfully maintained by a conſtant Variation.

P. Let me know what you underſtand by its being maintained by a conſtant Variation?

M. I am afraid I ſhall not be able to expreſs clearly a Thing which in its own Nature is not eaſy to be conceived.

P. It

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P. It ſometimes ſo happens indeed: But in ſuch Caſes Allowance is to be made, and the Words are ſuppoſed to convey more than they expreſs.

M. While the Moon here moves in her own Orbit round the Earth, a prodigious Force is conſtantly impreſſed upon her, which hath no Relation to her Motion in that Orbit, but to her moving in a parallel Direction with the rapid Motion of that very Body, about which ſhe muſt at the ſame Time revolve. Now that this parallel Motion to, and periodical Motion round the ſame Body, ſhould be made conſiſtent, appears to me wonderful above Expreſſion; and requires a conſtant, and nicely adjuſted Variation of this parallel Impreſſion in every Point of her Orbit.

P. Go on; I conceive what you ſay very eaſily.

M. As the Motion of the Earth is in a circular Orbit, an Impreſſion of Force parallel to the Direction of ſuch a Motion muſt be changed, and therefore renewed every Minute, as the Direction of the Motion itſelf is changed in every Point. When we look round, there is no Attraction here, nor ſtated mechanical Law (ſuppoſing Attraction

traction were *mechanical)* to ſuperſede this conſtant Impulſe in a different Direction: For you ſhewed abundantly juſt now, that the attractive Power of the Earth doth not in the leaſt contribute to it. And this *parallel Impreſſion* itſelf is to ſupply the Place of a projectile Force; as we ſaw, when it was firſt impreſſed on the *Primary* and *Satellite*, before the attractive Force of the Sun was ſuppoſed to act. So that the Impreſſion of this Force (as was ſaid) is to be changed, and therefore renewed every Minute, by an *immechanical Cauſe* * —— Beſides, while the Moon moves regularly round her *Primary*, in her proper Orbit; ſometimes ſhe gets before it, ſometimes ſhe returns back, anon ſhe overtakes it; and

* Leſt it ſhould be here ſurmiſed, that the attractive Power of the Sun may be ſufficient ſo to affect *this Force* impreſſed on the Moon, as always to bend her Motion into a Direction parallel to the Orbit of the Earth, in a mechanical Manner, and without a new Intervention of Divine Power; let it be conſidered that if, in the Conjunction, the Sun's Attraction were thus ſufficient to bend the Moon's Motion into a Direction parallel to the Earth's Orbit, (that is, into a concentrical Circle;) the Moon could never turn up again toward the Earth's Orbit, or leave that Circle. And if the Sun's Force be not ſufficient to give her Motion ſuch a Bent in the Point of Conjunction, it cannot be ſufficient when the Moon is at a greater Diſtance.

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often ſhe moves obliquely, or croſs-wiſe. Hence this *parallel Impreſſion* muſt ſometimes be ſtronger, ſometimes weaker, and the Quantity of it conſtantly varied, according to the different Part of her Orbit ſhe moves in; or there is an inconceivably nice Compoſition of two different Impulſes (the projectile Force, I mean, in her own Orbit, and this *parallel Impreſſion)* whereby they ſometimes conſpire, are ſometimes directly oppoſite, and often the one is made ſide-wiſe to the other. When their Directions conſpire in the Conjunction, what ſeparates them again? When they are contrary in the Oppoſition, what renews the leſſer Force which is once quite deſtroyed? When the Directions are oblique, what preſerves both Forces entire? There is nothing here like the *Axiom* you once told me of, *That a Body partakes of the Motion of its Place.* The Place of the Moon's Orbit is pure Space, which can neither be moved, nor impreſs a Force on any Body moving in it. From this it appears to me that not only the *parallel Impreſſion*, but the Moon's projectile Force in her own Orbit, is ſtill preſerved the ſame, not from any mechanical Cauſe, but the conſtant

conſtant Action of the Deity. And ſince both theſe Forces are always impreſſed, or renewed, in ſuch due Proportion that the one of them no more diſturbs the other (in their Effects I mean) than if it were not impreſſed, I cannot enough admire this new Inſtance of the Divine Power and Wiſdom in the Motions of theſe ſecondary Planets. Seventh Conference.

P. You have expreſſed this complex Appearance, *Matho*, as clearly to my Apprehenſion as the Nature of the Thing will allow. In the *Conjunction* the Moon's Motion in her own Orbit conſpires with this parallel Impreſſion, and adds to its Celerity; in the *Oppoſition* her menſtrual Motion is contrary to the other, and retards it; in all other Points of her Orbit they are oblique, leſs or more, and affect each other accordingly. But whether you conceive that the *parallel Impreſſion* is made ſometimes ſtronger, ſometimes weaker; or that both Forces are ſtill kept up to the ſame Quantity; we muſt ſtill have Recourſe to the immediate Power of the Deity, and give up all Explications by mechanical Cauſes. If the *parallel Impreſſion* on the Satellite were not inceſſantly renewed in a different Direction,

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according to the circular Orbit of the *Primary*, theſe two could not keep together in one Syſtem: Or if the Moon's proper projectile Force were not conſtantly renewed after the Oppoſition, ſhe could no longer roll about the Earth. For in that Point the weakeſt Force muſt be deſtroyed.

M. And this conſtant Miracle becomes manifold where four or five Satellites revolve about the ſame primary Planet: So that the Mind, which can hardly conceive this wonderful Adjuſtment of Forces in the ſimple Syſtem of the Earth and Moon, is quite confounded with the Variety of them in the more complicated Syſtems of *Jupiter* and *Saturn*.

P. And what is ſtill more wonderful, *Matho*, this conſtant renewing of the *parallel Impreſſion* will not be peculiar to the *Satellite* alone; but common to it with its Primary; if the ſecondary Planet does not preciſely revolve about the Center of its Primary, but together with the Primary rolls about a certain Point between them, called their *common Center of Gravity*. In this Caſe the tangential or projectile Force of the larger Planets, which hitherto we have ſuppoſed to be owing to one original Impulſe,

Impulſe, given them at the Beginning of their Motions, will as much require a conſtant Variation of Impreſſion, as that of the *Secondaries* themſelves. Seventh Conference.

XCV. *M.* Pray explain this Particular; for I am quite a Stranger to what you call the common Center of Gravity of two Bodies.

P. In Truth I'm afraid leſt it ſhould fatigue your Imagination too much, which cannot now be ſo briſk and ready as when we began: And this is no eaſy Speculation to one who has never heard of a Center of Gravity before.

M. If I do not underſtand what you ſay I ſhall be no wiſer than if you had ſaid nothing at all.

P. You muſt know then that the Center of Gravity of two Bodies (not to ſpeak of more) is ſuch a Point between them, about which if both roll, their centrifugal Forces will be equal, or balance each other; ſo that neither can carry off the other by its ſtronger Tendency to recede from the Center of its Motion. And therefore this Point is ſo much farther diſtant from the Center of the leſſer Body, as the Quantity

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of Matter in the other is greater: or (which comes to the ſame Thing) it is ſo much nearer the Center of the greater Body, as the Quantity of Matter in the other is leſs.

M. Give me an Example of this?

P. If the Quantity of Matter in the Earth be forty Times more than that in the Moon, their common Center of Gravity will be forty Times farther diſtant from the Center of the Moon, than from the Center of the Earth; that her larger Swing in moving round this Point may make up what ſhe wants in Matter to balance the centrifugal Force of the Earth, and hinder her from being drawn away. For a fortieth Part of the Matter with forty Times the Celerity will be equal to forty Times the Matter with once the Celerity. Therefore if we ſuppoſe the Diſtance between the Centers of the Earth and Moon divided into forty-one equal Parts, their common Center of Gravity will be forty of thoſe Parts diſtant from the Center of the Moon, and only one of them diſtant from the Center of the Earth.

M. I think I have a Notion of this from ſome Sort of Balances I have ſeen; where a Weight

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a Weight half as great only as another, was yet a counter-poise for that other, provided it were placed twice as far from the *Point* by which the Balance was suspended; here, I conjecture, half the Weight with twice the Celerity was equal to twice the Weight with once the Celerity.

P. You are very right: This is a good Example to give you a familiar Notion of the Center of Gravity of two Bodies.

M. But what do you mean by the Center of Gravity of more Bodies? For you mentioned that also.

P. In your Example you know if the two Bodies be suspended by their common Center of Gravity, neither of them will over-balance the other, more than if they were both placed in that Point.

M. Neither of them will.

P. Suppose then the *Beam* long enough, and a *third Body* (equal, for Instance, to a tenth Part of the Weight of both these Bodies taken together,) placed on the Beam at a Distance from them.

M. What then?

P. Then the Center of Gravity between this *third Body* and the *former two*, considered now as one Body, will be ten times more

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diſtant from *it*, than from their Center of Gravity: So that if the Beam were now ſuſpended by this Point, this *third Body* would be a counter-poiſe for both the former Bodies.

M. Then you ſuppoſe the *two former Bodies* to weigh exactly as if they were placed in their common Center of Gravity, in Order to find out the Center of Gravity between them and this third Body?

P. Exactly the ſame Way.

M. And *this Point* laſt found will be the common Center of Gravity of all three?

P. It will.

M. And if I were to find out the Center of Gravity between *theſe three* and a *fourth*, I ſhould ſuppoſe all three ſuſpended, or placed at their common Center of Gravity, and proceed as before; that is, as if there were but two Bodies?

P. You have it.

M. This is both eaſy and pleaſant.—— Pray let me mention a Particular I have often obſerved, which I think has ſome Relation to this.

P. I ſhall be glad to hear it.

M. When I have ſtruck againſt any Thing with a Stick, if the Stroke was too near

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near my Hand, or too near the End of the Stick, my Hand was ſtrongly ſhaken ſome how, and I felt Pain from the Stroke; but otherwiſe it was eaſy and not painful to me.

P. In this Caſe, *Matho*, there is a Point in the Stick, or in any Thing with which you ſtrike, called the *Center of Percuſſion*. When the Stroke falls on *that Point*, it is ſmooth and eaſy to the Hand; for the Parts of the Stick on each Side balance each other, and the Thing againſt which you ſtrike receives the whole Force of the Blow. But if the Stroke falls too near your Hand on this Side, or too near the End of the Stick on the other, your Hand bears a Part of the Force, and is ſeverely ſhaken by it, which occaſions Pain.

M. And whereabouts in the Stick may this Point, or *Center of Percuſſion* lye?

P. About two thirds of the Length of the Stick from your Hand; or one third of it from the other End.

M. Then this gives me ſome Idea of the Center of Percuſſion. ——

XCVI. But to return; Why do you ſuppoſe that the Earth and Moon ſhould

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revolve about their common Center of Gravity, rather than that the Moon ſhould revolve about the Center of the Earth, which revolves about no Center but the Sun, the common Center of the Motion of all the primary Planets?

P. The Earth and Moon, you know, mutually attract each other; and if we ſuppoſe no other Action to intervene, which may hinder the Earth to yield to the Moon's Attraction, it is impoſſible the Moon ſhould revolve about the Earth at Reſt, without its being brought ſtill nearer and nearer to the Moon, 'till at length they come cloſe together.

M. I own I do not conceive this at all.

P. Imagine the Moon to roll about the Earth at reſt, (no other Action intervening) and in that Caſe the mutual Attraction between them cannot bring the Moon nearer the Earth, becauſe ſhe has a centrifugal Force by her circular Motion, which hinders her from yielding to the Earth's Attraction: But the Earth having no ſuch centrifugal Force, as being ſuppoſed at Reſt, muſt yield to her attractive Power by little and little, 'till at length they meet each other.

M. Thus

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M. Thus far I ſee: Their Attraction would grow ſtronger and ſtronger, as they drew nearer, till at laſt they ruſhed towards each other.

P. That would be the Conſequence: But if, to prevent that, the Earth ſhould have a projectile Force impreſſed upon it, in a contrary Direction to the Moon's, and with a proper Celerity (*i. e.* ſo that its Celerity might be a fortieth Part of the Moon's,) then it will have an equal centrifugal Tendency, and their mutual Attraction will as little prevail upon it, as upon the Moon.

M. The Matter now is intelligible. If two unequal Bodies were tied together by a Rope or Cord, and a Force only impreſſed on one of them (the greater ſuppoſe) *That* would drag the other after it: But if a Force were impreſſed on both, ſide-wiſe to the Tenſion of the String, and in contrary Directions, ſo that the Velocity of the leſs were as much more than that of the greater, as the Quantity of Matter in it were leſs; they muſt both neceſſarily revolve about ſuch a Point as made their centrifugal Forces equal; that is, about their common Center of Gravity.

P. You

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P. You enter very naturally into the Thought.

M. Since the greater Body muſt always be nearer the common Center of Gravity. This brings to my Mind *Tycho Brahe*'s Syſtem of the Planets, where the Earth was ſuppoſed in the Center, with the Sun rolling about it: Which was like ſuppoſing a Mill-Stone rolling about a Pebble.

P. I am glad you remember ſo well that this obvious Reaſon eaſily ſhews the Abſurdity of that ingenious Fiction.

M. But in the preſent Caſe, Why do you make ſuch an Exception, *If no other Action intervene?*

P. Becauſe a ſtronger Action than their mutual Gravitation might hinder the Earth from moving thus about their common Center of Gravity, and then the Moon muſt revolve about the Earth as the Center of her Motion.

XCVII. *M.* I conceive it: But then, how do you ſhew that, if both of them revolve about the Earth as their common Center of Gravity, the *primary Planet* muſt conſtantly receive a Variation of Impulſe

pulſe in a different Direction, as well as the Satellite?

P. You know then both of them revolve about a Point (their common Center of Gravity) which revolves about another Point, (the Center of the Sun:) In this Caſe therefore it is the Center of Gravity that deſcribes a circular Orbit about the Sun, and neither the Earth nor the Moon, which revolve immediately about it. —— Now, tho' their Center of Gravity were at Reſt, both the Earth and Moon muſt receive a projectile Impulſe in contrary Directions, and with different Velocities, (as forty and one, to wit,) about this Point; juſt as it was in your Example of the two Bodies tied together with the Rope or String: For if one of them only received an Impulſe about *it*, and the other not; that other, wanting centrifugal Force to reſiſt their mutual Attraction, would be drawn nearer the Body which had centrifugal Force.

M. I perceive it muſt be ſo.

P. This would be the Caſe if their common Center of Gravity were at reſt, and the Sun abſent. But that *this Point*, about which they roll, may be carried in a cir-

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cular Orbit round the Sun, both of them muſt alſo receive an Impreſſion, always parallel to the circular Motion of *this Point*; juſt as the Moon, in the former Suppoſition, was to receive an Impreſſion always parallel to the circular Motion of the Earth.

M. I begin to penetrate a little into the Matter.

P. I ſay the Earth now, as well as the Moon, muſt receive an Impreſſion always parallel to the circular Motion of *this Point:* For if in the former Caſe the Earth's Attraction was not enough to carry the Moon along with itſelf round the Sun, without ſuch an Impreſſion; the Effect of that Attraction being but about 16 Feet in a Minute; ſo in this Caſe the Moon's Attraction would be leſs able to carry the Earth along, were not an Impreſſion made on it likewiſe; the Effect of her Force being but a 40th Part of 16 Feet in a Minute.

M. It is plain the Earth muſt receive an Impreſſion as well as the Moon.

P. Then the Direction of this Impreſſion muſt always be changed, and the Impreſſion itſelf therefore renewed, becauſe the Direction of the *moving Point*, to which

it muſt ſtill be parallel, is always changed; ſince it deſcribes a circular Orbit round the Sun. For as, in the former Caſe, the Impreſſion made on the Moon was ſtill to be parallel to the Earth's circular Motion, and therefore ſtill to be renewed; ſo in this Caſe, the Impreſſion made on the Earth is ſtill to be parallel to the circular Motion of their *Center of Gravity*; and therefore ſtill to be renewed.

M. You have now gone through the whole Argument, *Philon*, Step by Step, ſo clearly, that I perceive the Neceſſity of the Reaſons all along; and it is as you ſaid. This makes the *projectile Force* of the primary Planets, which otherwiſe would be owing to one original Impulſe given them at the Beginning of their Rotation round the Sun, as much to require a conſtant Variation of Impreſſion, as that of the Secondaries themſelves. You raiſed my Admiration before, when in our preceding Conferences you ſhewed me by what wonderful Means a primary Planet revolves about the Sun: But now when I conſider what conſtant Attention, and manifold Impreſſions it requires, to make *a ſecondary Planet* revolve about *a Center*, which itſelf muſt revolve about

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about *another Center*; Words lend but a feeble Aid to repreſent my Aſtoniſhment. A ſimple circular Motion requires a conſtant Change of Direction, and therefore a conſtantly renewed Impulſe: But when one circular Motion is blended with another, and both are wrought into one (if I may ſo ſay) in the ſame Body, without Diſorder or Confuſion; and when this amazing Compoſition is multiplied with the Number of Satellites in the ſame Syſtem; the Heart of Man cannot ſufficiently admire the Wiſdom of the *Creator* in contriving, nor his Power and Goodneſs in the conſtant Execution of ſuch a wonderful Work!

P. Hence, *Matho*, it appears more and more evident, how little Satisfaction there is in Philoſophy, if we exclude the immediate Action of the Deity. The Knowledge of the Laws of Nature is only the Knowledge of the Laws by which the *Creator* acts in preſerving the Univerſe. We attempt an impoſſible Thing when we endeavour to explain theſe Motions without his immediate Action. And *even They* paſs over the Conſideration of many Particulars, who acknowledge the immediate Hand of the *Almighty* in conſtantly renewing the centripetal

centripetal Impulſe; but imagine that the projectile Force once impreſſed on the Planets hath remained unvaried ſince the Creation of the World, without the farther Interpoſition of the Deity. Seventh Conference.

XCVIII. *M.* I think I now underſtand ſomething more of the compound Motion of the ſecondary Planets than formerly I did; or at leaſt I ſee how difficult ſuch a Motion is to be underſtood: And likewiſe from what you ſaid in the Beginning of our Diſcourſe, I fancy I can gueſs at the Reaſon why the Action of the Sun, tho' predominant over the whole planetary Syſtem, does not diſturb, or confuſe, the Motion of the ſecondary Planets, in theſe leſſer Syſtems of *Saturn*, *Jupiter*, and our *Earth*.

P. What is the Reaſon you would aſſign, why this does not happen?

M. You obſerved then, from what we had ſaid before, That the Attraction of the *great Bodies* in our Syſtem does not immediately ceaſe at their Surfaces, but prevails through a certain ſpherical Space round them, according to the Quantity of Matter each of them contains; which occaſions

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ſions the *relative downward* and *upward* we have ſo often ſpoke of, peculiar to every great Body in the Syſtem. Hence I ſuppoſe, if a Body were placed in any of theſe particular Spheres, it would fall to that Planet within whoſe Attraction it were thus placed, and not to the Sun, or any other Planet. And on this account the Action of the Sun does not ſeparate the Bodies in any of the leſſer Syſtems; becauſe the Satellites are within the prevalent Attraction of the Primary Planets about which they roll.

P. You go on here at a great rate, *Matho*, without any Aſſiſtance.

M. The Subject appears natural and eaſy, from what we have ſaid before.

P. But how could you ſatisfy another Perſon, that the Force, whereby a Satellite is retained in its Orbit about the Primary Planet, points to that Planet?

M. The ſame way that I could ſatisfy him that the Force, whereby the Primary Planets themſelves are retained in their Orbits about the Sun, points to the Center of the Sun. I ſee plainly an Impoſſibility that any Body ſhould move in a circular Orbit about a Center in a free Space, unleſs it were conſtantly urged by a Force pointing to that Center,

Center, compounded with a projectile Tendency, or a Tendency to recede from that Center in every point of its orbit. This must hold as much with respect to one Center as another; as much with respect to the Centers of the Primary Planets about which their Satellites revolve, as with respect to the Center of the Sun about which the Primary Planets revolve. You alledged indeed, as a Proof of this, that where there are more Satellites than one in the same System, the Squares of their periodical Times round the Primary, and the Cubes of their Distances from it, are in the same Proportion; which is the Law that obtains with respect to the Motions of the Primary Planets themselves about the Sun: But whatever Strength there may be in that Argument, it depends on you to make me understand it. Though even without that, the Case seems to be plain to Reason and common Sense. For tell me, does not the *centrifugal Force*, arising from the circular Motion, balance the *centripetal?*

P. Certainly.

M. If then the circular Motion were stopt, or if the Satellite had no centrifugal Force, what would be the Effect of the *centripetal?* Would it not draw down the Satellite to the

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Center of the *Primary?* Or in reſpect of *what Center* is it a centripetal Force?

P. You prove this Matter convincingly enough.

M. And on this Principle it is, I ſuppoſe, that you ſaid before, the Moon would be drawn down in a Minute ſome more than ſixteen Feet, towards the Center of the Earth?

P. It is: And on the ſame Principle too Mathematicians ſhew, in what Time any of the Satellites would fall to the Center of its Primary; or in what Time the Primary would fall to the Center of the Sun.

M. There muſt be ſomething therefore under this Queſtion, ſince it is ſo plain; otherwiſe you had not made a Queſtion of it; and I muſt endeavour to be upon my guard.

P. Tell me next, How are theſe particular Spheres of Attraction of the Planets ſeparated from the general Attraction of the Sun, which obtains over the whole Planetary Syſtem?

M. As the Attraction of any Planet (our Earth, for Inſtance) draws a Body towards its Center, and the Attraction of the Sun draws a Body towards his Center; there muſt

be a *Limit* betwixt them, where the contrary Attractions are equal, and where, if a Body were placed, it ſhould have a Tendency to neither. From the Earth on the one Side, or the Sun on the other, to this Limit is *upward:* And contrarily, from this Limit to either is *downward.* Gravity therefore (as you obſerv'd) is but relative, and no way eſſential to Matter; ſince a Body placed at this Limit would gravitate to neither Center.

P. You are certainly in the right, *Matho:* For as the Earth attracts a Body at its Surface more ſtrongly than the Sun attracts it; and as the Sun attracts a Body at his Surface more ſtrongly than the Earth does; and ſince the Force of both Attractions decreaſes in a certain Proportion, as the Diſtance from the Sun or Earth increaſes; it muſt be, that in ſome certain Point between them their attractive Forces ſhould be equal.

M. This is what I meant: And therefore if a Satellite keeps within this Limit, it muſt revolve about its Primary, within the Sphere of whoſe Attraction it is. Hence likewiſe I ſuppoſe, the greater the Sun's Diſtance is from the Earth, or any other Primary Planet; that is, the larger the Solar Syſtem is ſuppoſed to be; the larger the Sphere of Attraction of

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the Earth, or any other Planet, muſt be of conſequence; or, the farther *this Limit* between the Sun and it will be removed from any other Body in the Syſtem.

XCIX. *P.* It is very natural, *Matho*, for you to imagine ſo; but in Reality the thing is directly contrary to what you ſuppoſe.

M. Pray ſhew me my Miſtake in this Particular.

P. I muſt firſt tell you that the Force of Attraction decreaſes in receding from the Center of the Sun (or of any other attracting Body) as the Squares of the Diſtances from that Center increaſe; and contrarily.

M. Explain this by an Example.

P. The Sun at twice the Diſtance attracts a Body but with a fourth Part of the Force, it would do at once the Diſtance; and at thrice the Diſtance, but with a ninth Part of the Force.

M. I underſtand; and at four times the Diſtance, but with a ſixteenth Part of the Force: And ſo on.

P. It is ſo: And when the Diſtance is leſſened; at half the Diſtance he attracts four times more ſtrongly, at a third Part the Diſtance, nine times more ſtrongly, *&c.*

M. This

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M. This is a Conſequence of the laſt Caſe.

P. Since then the Attraction decreaſes, as the Squares of the Diſtances increaſe; and increaſes as the Squares of the Diſtances decreaſe; both Caſes are thus briefly expreſſed. *The attractive Force is inverſely as the Squares of the Diſtances from the attracting Body.*

M. This is ſhort indeed, and plain too, when one conſiders the Examples. ——

P. Thus the Attraction decreaſes, as the Diſtance of the Sun from the Earth is increaſed. Let us conſider next how it will be increaſed, notwithſtanding the Sun always appears of the ſame Magnitude whatever his Diſtance be: For as the Attraction grows leſs in the one Reſpect, it grows greater in the other.

M. Pray ſhew me how that is.

P. If the Sun were at twice the Diſtance, his Diameter muſt be twice as big, that it may appear but equally large to us: As a *Pole*, or *Tree*, that it may appear to the Eye at twice the Diſtance as high as another at once the Diſtance, muſt in reality be twice as long.

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M. It muſt be ſo according to common Senſe, and by an eaſy Propoſition in the *Elements* of *Euclid*.

P. Therefore at twice the Diſtance the Sun's *Diſk*, or Surface, muſt in reality be four times as large, as at once the Diſtance, that he may appear to the Eye but equally big.

M. This I think I likewiſe underſtand: For a Square whoſe Side is two Feet, is four times as large as another whoſe Side is but one Foot.

P. Right. Hence the Sun at twice the Diſtance muſt have eight times the Quantity of Matter in him, to appear equally large to our Eye, he would need at but once the Diſtance: For a Cube whoſe Side is two Feet, or a Sphere whoſe Diameter is two Feet, is eight times as big as another whoſe Side, or Diameter, is but one Foot.

M. It is ſo indeed.

P. And by the ſame ſort of reaſoning, going on with the Steps accurately, you will find that the Sun at thrice the Diſtance muſt have twenty-ſeven times the Quantity of Matter in him, to appear of an equal Diameter to the Eye, that he would require at once the Diſtance. And at four times the Diſtance,

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Diſtance, he muſt have ſixty-four times the Quantity of Matter in him: And ſo on.

M. I ſee already that theſe are but Repetitions of the firſt Argument, on the Suppoſition of different Diſtances of the Sun.

P. That is to ſay then, the Quantity of Matter in the Sun muſt be as the Cubes of the Diſtances we ſuppoſe him to be at from us.

M. Becauſe his Diameter is increaſed with his Diſtance; and his Matter with the Cubes of his Diameter?

P. Right.

M. What do you infer from all this?

P. At twice the Diſtance the Sun will attract four times leſs upon the account of his double Diſtance; but then he will attract eight times more upon the account of his octuple Matter: That is, in effect, he will attract twice as ſtrongly as at once the Diſtance.

M. You will leave me behind, if you go on ſo faſt with your Argument.

P. Take it thus then. An equal Sun at twice the Diſtance would attract but with a fourth part of the Strength of our Sun at half the Diſtance, being twice as remote from us: But that he may appear of an equal

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Bigneſs to us with our Sun, he muſt have eight times the Quantity of Matter in him; and on that account muſt attract eight times more than this fourth Part: That is, he will attract twice as forcibly as at once the Diſtance.

M. I underſtand it now: His Diſtance leſſens his Attraction, but his Quantity of Matter (growing faſter than his Diſtance) increaſes it more than it is leſſened.

P. It is ſo: And by the ſame Argument repeated, you will perceive that, at thrice the Diſtance he will attract thrice as ſtrongly; and at four times the Diſtance four times as ſtrongly as when we ſuppoſe him at once the Diſtance.

M. It will indeed follow.

P. All this is thus compriſed in few Words. Since the Attraction of the Sun decreaſes inverſely as the Squares of his Diſtance, but increaſes directly as the Cubes of his Diſtance; abſolutely ſpeaking it will be increaſed as his Diſtance directly. Thus if his Diſtance be 20000 Semi-diameters of the Earth from us, he will attract the Earth twice as forcibly as if it were but 10000 Semi-diameters: and if it be 30000 Semi-diameters, thrice as forcibly: And ſo on.

C. *M.* You

C. *M.* You have given me a good deal of Light into this matter, in a ſhort Time: And from this I ſee; the Attraction of the Earth remaining ſtill the ſame, whatever the Sun's Diſtance be; the farther we ſuppoſe the Sun removed from the Earth, the nearer this *Limit of equal Attraction* will approach to the Earth; and the leſs we ſuppoſe his Diſtance from us, the farther *that Limit* will recede from it: The contrary of which I ſhould have inferred, had I been left to my ſelf.

P. You may likewiſe be ſatisfied of this from another Conſideration: For the greater the Sun's Diſtance from the Earth is, the larger its annual Orbit muſt be, as having a larger Radius; and the larger the Circle is, which is run over by the Earth in the ſame Time, the greater the Earth's centrifugal Force muſt be: The centrifugal Force in this Caſe increaſing directly with the Radius, or Diſtance of the revolving Body.

M. I ſee it plainly: And the greater the Earth's centrifugal Force is, the ſtronger the Sun's Attraction upon it muſt be, to keep it from flying off; and the ſtronger the Sun's attractive Force is, the nearer the Point, where

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where the Earth's Force and his would balance each other, muſt approach to the Earth. So that I am ſatisfied now upon a double account that this is ſo. But pray might not *this Limit* be determined, according to any particular Diſtance the Sun were ſuppoſed to be at from the Earth?

P. It might with no great Difficulty.

M. Then I think it would be very agreeable to aſſign that *Boundary*, beyond which our Moon could not roll. We ſhould thus ſee, upon the Suppoſition of any particular Diſtance, how nearly ſhe were hemmed in; or if there were room for another Satellite to revolve without her. I ſhould even think that aſſigning this Boundary might be of uſe to help to determine the Sun's real Diſtance from us; in caſe, on the common Suppoſition, *it* were found to be ſo near the Moon's Orbit, that the Sun could not be farther removed from us, without *this Limit*'s encroaching on the Space in which the Moon were to revolve.

P. Here we muſt proceed by degrees, *Matho*; for though what we have hitherto ſaid ſeems plain to you and me, yet it will not be eaſily allowed that the Moon's Motion would be diſturbed, though the *Limit* of

of *equal Attraction* between the Sun and Earth fell within her Orbit.

M. Would the Moon revolve as a Satellite about the Earth, if she were more attracted by the Sun than by the Earth in the interior part of her Orbit?

P. This Particular of disturbing the Motion of the Moon is explained in a different manner. There is an *Axiom*, or *Proposition* in Philosophy, which shews, we are told, that the Moon's Course might be preserved regular about the Earth, tho' she were a thousand times more attracted towards the Sun than to the Earth *.

M. A thousand times! Pray what is the Proposition?

P. It is this; *If Forces in parallel Directions act equally on all the Bodies of any System, their relative Motions cannot thereby be disturbed.*

M. I remember you mentioned something like this Axiom before, when you shewed me the Difference between *absolute* and *relative Motion*; and then I thought I saw in what Sense it was true: But as it is applied

* See the History of the Works of the Learned, for *October* 1738. Art. XXX. Pag. 269.

here

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here I do not ſee the Force of it, and think it is ſtrained too far.

P. How did you underſtand it then?

M. I ſuppoſe the Axiom was to be ſo underſtood, that the *Parallel Forces* impreſſed on the ſeveral Bodies of the Syſtem were not to deſtroy the particular Forces, whereby thoſe Bodies moved relatively among themſelves: Or, that all the Bodies of the Syſtem yielded equally to, and were equally carried along (in the immenſe Space ſuppoſe) by the parallel Forces. And on theſe Conditions the Senſe of the Axiom ſeems plain and obvious: But in the preſent Caſe, where the *Earth* and *Moon* revolve about the Sun as a Center, the Circumſtances are very different; therefore the Axiom ſeems leſs applicable. The Sun in the Conjunction of the Moon attracts her one way, and the Earth (which doth not yield to the Sun's Force, ſo as to draw nearer him) attracts her the other: And in this Caſe, if the Sun's Force in drawing the Moon down towards himſelf were a thouſand times greater than the Earth's in drawing her the contrary way; or if the *firſt* were but barely equal to the *laſt*; then the Axiom, inſtead of ſhewing that the relative Motions of the Syſtem could not

not thereby be diſturbed, ſeems to me to ſhew that the *Syſtem itſelf* ſhould be quite diſſolved. Seventh Conference.

CI. *P.* But here you leave out the principal Condition, which is, *That the Earth be equally attracted with the Moon.*

M. That Condition, as I take it, does not ſhew the Thing intended. For the Earth's centrifugal Force hinders it from drawing nearer the Sun, or being carried along with his Attraction, how great ſoever it may be ſuppoſed to be: But when the Moon deſcends to her Conjunction, her centrifugal Force in her own Orbit rather conſpires with the ſuperior Force of the Sun. And tho' we ſhould ſuppoſe that the *Impreſſion* we ſpoke of before (which is ſtill made on the Moon parallel to the Earth's circular Motion) hindered her from deſcending to the Sun; yet it could never aſſiſt her in riſing after her Conjunction through the oppoſite part of her Orbit; ſince this Impreſſion would carry her in a concentrical Circle to the Earth's Orbit, or bend her Courſe the contrary way. Of the *four Forces* therefore, which act conſtantly upon her, *three* reſiſt her riſing after the Conjunction; *viz.* the Sun's attractive Force, the

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the Force impreſſed always parallel to the Earth's Motion, and her centrifugal Force in her own Orbit: Whence we have nothing left to make her mount towards the Earth's Orbit, but the weaker Attraction of the Earth itſelf. It is here I conceive where the Difficulty lies; and in turning up again it appears to me the prevalent Attraction of the Earth is neceſſary: Otherwiſe ſhe would move from her Conjunction (not indeed down to the Sun) but forward in a ſeparate Orbit of her own, incurvated to the Sun, and bent from the Earth, which muſt ſeparate her from rolling about the Earth as a Satellite.——

P. Have you done?

M. I may not perhaps have ſpoke ſo intelligibly as I could wiſh; but what I mean in ſhort is this. The Orbit of the Earth is every where equally diſtant from the Sun; therefore the Earth never yields to the Sun's Attraction: For as its Gravitation would carry it down to the Sun, and its projectile Force would carry it to a greater Diſtance from him; by a Compoſition of both Forces it keeps ſtill at an equal Diſtance from him. But the Moon ſometimes deſcends nearer the Sun, and after that aſcends to a greater Diſtance

ſtance from him: And this riſing to a greater Diſtance is not relative but abſolute. For when the Diſtance between two Bodies is changed, one of the two at leaſt muſt have a *real* and *abſolute Motion*; and it will not be ſaid, I believe, that this *real Motion* belongs to the Sun. Now when the Moon moves abſolutely to a greater Diſtance from the Sun, it muſt be by moving againſt the whole Force of his ſtronger Attraction, by means of the weaker Force of the Earth; which appears to me really impoſſible. And if this be ſo, it muſt be a falſe Explication of the Axiom, which makes it contradict a plain and ſelf-evident Truth, *viz. When two unequal Forces are at once impreſſed on the ſame Body in contrary Directions, it muſt yield to the ſtronger, and not to the weaker.*

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P. I both underſtand what you ſaid before, and what you ſay now, very well; nor do I ſee at preſent what can be reply'd.

M. It appears to me likewiſe, that we may come to the Solution of this Difficulty very eaſily thus. Imagine the Earth to ſtand ſtill in the ſame point of its Orbit, hindered by ſome Power or other from yielding to the attractive Force of the Sun, while the Moon performed her menſtrual Courſe

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Courſe about it: And if the Attraction of the Sun were ſtronger than that of the Earth, ſhe muſt yield to that prevalent Force, and be carried off from the Earth. Now when the Earth has its projectile Force impreſſed upon it, no new Force is impreſſed upon the Moon, except that in a parallel Direction always to the Orbit of the Earth: And *this*, as has been obſerved, could never help to carry her upward from the Conjunction; but would rather bend her Courſe concentrical to the Earth's.

CII. *P.* Your Reaſoning becomes clear and intelligible, *Matho*, by arguing thus from the Point of the Moon's Conjunction: But if the Limit of equal Attraction between the Earth and Sun lay within the Moon's Orbit, it ſeems no leſs true, that ſhe would be drawn out of her Courſe from any Point in the interior half of her Orbit.

M. Pray make me underſtand how this could be.

P. If this Limit were at the Diſtance of 40 Semi-diameters of the Earth *(ex gr.)* from its Center, that is, 20 Semi-diameters within the Orbit of the Moon; imagine a Semi-circle concentrical to the interior half of her

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her Orbit, deſcribed through this Point. And ſince the Attraction of the Sun is nearly as great at the Earth's Orbit, as at the Point of the Moon's Conjunction, this Semi-circle will ſhew every where the Limit of equal Attraction between the Sun and Earth; and therefore it ſhews that the Moon is within the ſtronger Attraction of the Sun through the whole interior half of her Orbit.

M. It is very plain. I conceived the Limit of equal Attraction confined to one Point; namely, in a Line reaching from the Center of the Earth to the Center of the Sun: But this Semi-circle ſhews me the whole Bounds of the Sphere of the Earth's Attraction, with reſpect to the Sun. For if the Semi-circle were turned round on its Radius which paſſes through the Center of the Earth, it would form an Hemiſphere circumſcribing the Earth's Attraction, and dividing it from the Sun's ſuperior Force.

P. This ſeems to me a natural Conception of the Caſe.

M. If then we have reaſoned rightly hitherto, this Condition, I think, ought to be added to the *Axiom* above; *viz.* Not only that the parallel Forces act equally on all the Bodies of the Syſtem; but that the whole

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Syſtem yield to theſe Forces, or be equably carried along by them. Otherwiſe we ſhall ſo explain *this Propoſition*, as to make it contradict the ſelf-evident Truth I mentioned juſt now.

P. Theſe are the Conditions on which you ſaid the Senſe of the Axiom was plain and obvious. Now it would much conduce to the clearing up of this whole Affair, if you could ſhew by plain Examples that the Axiom holds on theſe Conditions, and cannot hold without them.

M. Let me take a little Time to digeſt my Conceptions.

P. Take your own Time. ——

M. Let us firſt ſuppoſe that two Bodies were carried along in a free ſpace, with equal Celerity, and in the ſame Direction, by the parallel Forces. They would then be relatively at reſt, or they would not change Diſtance with reſpect to each other: And in this caſe it is eaſy to ſee that a ſmall Force might make them approach to, or recede from one another. Let them be ten Feet aſunder, and carried down at the rate of ten Feet in a Minute; and let the *laſt*, or *greateſt* of the two, attract that which is before it, at the rate of one Foot in a Minute.

I chooſe

I chooſe theſe ſmall Numbers and Quantities, that the Imagination may not be perplexed with Diſtances and Forces almoſt incomprehenſible. Seventh Conferen e.

P. You do right to make the Suppoſition as ſimple as poſſible: That is the readieſt way to come at the Truth.

M. In theſe Circumſtances the *two Bodies* would come together in ten Minutes, after the *uppermoſt* or *laſt* had moved an hundred Feet, and the *undermoſt* ninety: For here in every Minute the Motion of the *under Body* is retarded one Foot by the Attraction of the *upper*; and in effect it is the *upper Body* which approaches the *lower*, or runs over the whole relative Diſtance between them: Or it is the *upper Body* that deſcends with the parallel Force in this caſe, and not the *under Body* that mounts againſt it. That I take to be an abſolute Impoſſibility. But now if we ſhould ſuppoſe the *upper Body* to be detained in any manner, or hindred from being carried along by this parallel Impreſſion, while the *leſſer* and *lower Body* were left to follow its Impulſe; this laſt would then be carried down from the other at the rate of nine Feet in a Minute; which is the Difference between the Effects of the two Forces.

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P. All this is undeniable.

M. Let us farther ſuppoſe while the *upper Body* remains fixed and immoveable, that the *under Body*, ten Feet diſtant from it, receives a tangential Impulſe, in ſuch Proportion as would make it revolve about the other in a Circle, if the parallel Forces did not act; and it is equally undeniable that this Body could not riſe againſt the parallel Force, which is ten Times ſtronger than *that* wherewith it is attracted to a Center. For the whole Force of the Attraction is not oppoſed to this ten-fold greater Force, but in one Point.

P. If *one Degree* of Force overcome *ten*, certainly nine of them muſt be overcome by nothing.

M. Laſtly, If we ſhould now ſuppoſe the *upper Body* not fixed, but moving along by the parallel Impreſſion, the *under Body* receiving the tangential Impulſe, as before, would then revolve about it; not by riſing abſolutely againſt a greater Force, but by the other Body's falling down, and its geting relatively to the upper Side.

P. It appears to me, *Matho*, you have purſued your Suppoſition fairly enough, and ſhewn what you undertook.

CIII. *M.* It

CIII. *M.* It ſhews, if I have repreſented Things right, that when both the Bodies are carried equally along by the parallel Forces, their relative Motions are not thereby diſturbed; but that without this Condition the Syſtem itſelf is diſſolved. For where the *upper Body* was ſuppoſed not to be carried along, the *under Body* was carried off from it: Nor could *this laſt* revolve about it then in a Circle, though impelled by a projectile Force. And this is applicable to the Moon, if the Limit of equal Attraction between the Sun and Earth fell within her Orbit. She would be carried off by the ſtronger Force of the Sun in every Conjunction: Unleſs indeed we ſhould have Recourſe to the *Interpoſition of the Deity* to prevent this. Which, if it could be ſhewn neceſſary I ſhould not be againſt: But for one to have Recourſe to ſuch Interpoſition here, though it were neceſſary, would be to give up the Axiom.

P. More, I think, needs not be ſaid on this Head.

M. We may vary the Conditions of the Suppoſition a little, till we come to the Circumſtances, in which only the Moon, as I

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conceive, could revolve about the Earth. —— Thus, while the parallel Forces carry along the two Bodies at the Rate of ten Feet in a Minute, we may ſuppoſe that the *upper Body* attracts the *lower* juſt ſo much in that Time: In which Caſe the *lower Body* would move neither Way, but remain abſolutely at Reſt; and the *upper* would run over the whole Diſtance between them. If here the *lower Body* received a projectile Impulſe in due Proportion, it would revolve about the *other*, not by riſing abſolutely againſt an equal Force; but by the *upper Body*'s being carried down, and coming in below it. But if we ſhould ſuppoſe the *upper Body* fixed, ſo as not to yield to the parallel Force, the *other* without a tangential Impulſe would remain ſuſpended between equal Forces, at the Diſtance of ten Feet ſtill from the *greater*: And if this *leſſer Body* received a tangential Impulſe, it would then be thrown off at a Side from the *greater*; but could not revolve about it. And this would be the Caſe between the Earth and Moon, if the Limit of equal Attraction fell upon the Moon's Orbit; or if ſhe were equally attracted

tracted by the Earth on the one Side, and the Sun on the other. Seventh Conference.

P. I have nothing to reply; every Thing ſeems as plain here as in the former Caſe. ——

M. We may in the laſt Place ſuppoſe that the parallel Forces impelled the two Bodies at the Rate of but one Foot in a Minute, while the *upper Body* attracted the *lower* at the Rate of nine Feet in that Time. And in theſe Circumſtances the *upper Body* would only move one Foot by the Force of the parallel Impreſſion, while the *leſſer* moved nine Feet againſt it: But here it moves by the ſtronger Force, and the whole Syſtem yields to the parallel Impreſſion a Foot in a Minute. And though now the Deſcent of the *greater Body* were impeded, the *under Body* by this ſtronger Attraction would nevertheleſs come up to it. If then *this laſt* received a projectile Impulſe, to give it a centrifugal Tendency, it would revolve about the *other* as a central Body, being within the Sphere of its more powerful Attraction, and having no where in its Revolution a ſuperior Force to overcome. — Nay, though now both Bodies ſhould receive an Impulſe always in parallel Direc-

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tions, and at right Angles to the firſt parallel Forces; or tho' the firſt parallel Forces now tended to a diſtant Center, ſo that *this Syſtem* revolved about that diſtant Center; the *leſſer* of the two Bodies would ſtill perform its Revolutions about the *greater*; all theſe different Impreſſions being ſtill regularly maintained by ſome *powerful* and *mighty Hand*. Which is exactly the Caſe of the Moon, more powerfully attracted by the Earth than by the Sun; or when the Limit of their equal Attraction falls without her Orbit.

P. To uſe your own Words, *Matho*, the ſame Things are ſo often to be named, and the Conditions ſo often to be repeated, that there is ſome Difficulty in following the different Steps of your ſeveral Suppoſitions: But when they are diſtinctly conceived, the Reaſoning ſeems very cloſe. From the *firſt Suppoſition* it appears that the Moon could not revolve about the Earth, if the Limit of equal Attraction between it and the Sun fell within her Orbit; and the *ſecond* ſhews that it would not be enough to make her revolve, though that Limit coincided with her Orbit. Whence it muſt fall without the Space ſhe revolves in, according to the

Condi-

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Conditions of the third Suppoſition. But it is certainly Time now to leave this Subject, ſince we have nothing more to ſay about it.

M. Permit me firſt to aſk you a few Queſtions.——

CIV. Pray tell me, does any of the Diſtances aſſigned to the Sun bring *this Limit* of equal Attraction between the Earth and him, within the Orbit of the Moon?

P. If the Sun's Diſtance from us were 34000 Semi-diameters of the Earth, as ſome have ſuppoſed; that *Limit* would fall, at a middle Rate, 26, and ſometimes 29, Semi-diameters of the Earth, within the Moon's Orbit; that is, about 104000, or 116000 Miles nearer the Earth than the Moon.

M. Then that Diſtance muſt certainly be too great; for it is inconceivable that ſuch a large Portion of the Moon's Orbit ſhould lie within the Regions of the Sun's ſtronger Attraction.

P. The whole interior Half of her Orbit, *Matho*, would then lie a great Way within his ſtronger Attraction; as has already

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ready been obſerved: In which Caſe, the Earth's Force on the Moon would ſometimes be little more than a fourth Part of the Sun's Force upon her. And here it is very remarkable, that the weaker the Earth's Force were on the Moon in Compariſon of the Sun's, the more equal the Sun's Force would be on both the Earth and Moon, and the Directions, in which it acted on both, more nearly parallel: So that the Conditions required, according to the aforeſaid Explication of the Axiom, for diſturbing the Moon's Motion leaſt, *(viz.* That the Sun attract both the Earth and her equally, and in parallel Directions,) would be attended with another Condition, which would diſſolve it quite; namely, a great Exceſs of the Sun's Force above the Earth's upon her. And theſe inconſiſtent Conditions muſt always increaſe together.

M. Let me conſider this a little, —— The greater the Sun's Diſtance from us is, the more equal his Force upon the Earth and Moon will be; becauſe the Difference between the Squares of the Diſtances of the Earth and Moon from him muſt be the leſs. And likewiſe the greater his Diſtance is, he muſt attract both the more nearly in

parallel Directions. But the greater his Diſtance is, the nearer the Limit of equal Attraction betwixt him and the Earth muſt approach to the Earth; or, the leſs the Earth's Force on the Moon muſt be in Reſpect of his. —— I ſee it very plainly, *Philon*; it is as you ſay. *Theſe inconſiſtent Conditions* muſt increaſe together. And this Conſideration ſeems to make the Explication of the Axiom ſomewhat irreconcileable to itſelf: For ſurely it could not be pretended that the Motion of the Moon would be more irregular, if ſhe were more attracted by the Earth than by the Sun; and yet the greater the Earth's Attraction were upon her, the leſs equal ſhould the Sun's Action be on both her and the Earth. —— Pray inform me next, if the *Limit of equal Attraction* between the Sun and *Jupiter*, or between the Sun and *Saturn*, fell within the Orbits of their Satellites; could that remarkable Proportion be then obſerved between the Cubes of the Diſtances and the Squares of the periodical Times of thoſe Satellites?

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P. It could not; for that Proportion is a neceſſary Conſequence of thoſe Satellites being attracted to the Centers of their reſpective

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ſpective Primaries, by the ſame Law as the Primaries are attracted to the Center of the Sun: That is, that their Gravitation to their Primaries be increaſed, as the Squares of their Diſtances from theſe Primaries decreaſe. Which Law could not obtain, if they gravitated more to the Sun than to their primary Planets.

M. It ſeems then, what could not agree to the Syſtems of *Jupiter*, or *Saturn*, could as little agree to the Syſtem of the Earth and Moon. For, tell me, if 3 or 4 Moons revolved about our Earth, would not they obſerve the ſame Proportion between the Cubes of their Diſtances and Squares of their periodick Times.

P. They would obſerve the ſame Proportion; for they would gravitate the ſame Way to the Earth, as the Satellites of *Jupiter* or *Saturn* do to thoſe Planets. And it is obſervable here, *Matho*, that the *great Author*, to whom we owe the Diſcovery, and whole Theory of Gravitation, makes the ſame Suppoſition of more Moons revolving about our Earth; and concludes they would all obſerve this Proportion, and therefore the fundamental Law of Gravitation, where the attracting Forces are reciprocally

procally as the Squares of the Diſtances from the attracting Body *.

M. But they could not obſerve that Proportion, nor this fundamental Law, if they were a thouſand Times, or twice, or but more attracted to the Sun, than to the Earth?

P. They could not then ſo much as revolve about the Earth, if we have reaſoned rightly on this Point before. ——

M. Abſolutely ſpeaking, according to this Senſe of the *Axiom*, it is poſſible that the Moon might revolve about the Earth, though the Limit of equal Attraction between the Sun and it approached to its very Surface?

P. That is too extravagant a Suppoſition, *Matho*, and makes the Earth's Attraction of little or no Uſe at all to the Moon's revolving about it.

M. Yet it ſeems a genuine Conſequence of what is aſſerted: For why ſhould any

* Si Lunæ plures circum terram revolverentur, perinde ac fit in Syſtemate *Saturni* vel *Jovis*: harum tempora periodica (per argumentum inductionis) obſervarent legem Planetarum à *Keplero* detectam, et propterea harum vires centripetæ forent reciprocè ut quadrata diſtantiarum à centro terræ. *Philoſoph. Nat. Princip. Math.* Lib. 3. Schol. Prop. 4.

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Regard be had to the Earth's Attraction, if the Moon might revolve about it, and yet gravitate a thouſand Times more to the Sun? Or is it impoſſible that the Sun ſhould attract at the Surface of the Earth, as ſtrongly as the Earth itſelf?

P. It is poſſible more Ways than one: But in that Caſe all Bodies on the Surface of the Earth would be looſe, or in Suſpenſe between two equal and oppoſite Attractions, and could not therefore revolve with the Earth on its Axis: Their centrifugal Force would throw them off towards the Sun.

M. Might not the Moon revolve about the Earth at four or five Times the preſent Diſtance from it; provided the Sun attracted the Earth and her equally?

P. Pray when will you have done with your Queſtions?

M. Very ſoon: Anſwer this.

P. If the Sun were at ſuch a Diſtance as to attract the Earth and Moon equally, in that Caſe the Limit of equal Attraction would draw nearer the Center of the Earth, or fall more than 200 of its Semi-diameters within the Orbit of the Moon, when ſo far removed.

M. Theſe

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M. Theſe ſeveral Conſequences ought, I think, to have been conſidered.——You ſaid that the Moon, by her Gravitation to the Center of the Earth would fall 16 or 17 Feet towards it in a Minute?

P. So much ſhe is attracted from the Direction of her projectile Force in that Time; as the ſame *great Author* has ſhewn.

M. And that on theſe Principles the Time of her falling quite down to the Earth is eaſily computed?

P. With no great Difficulty.

M. Now I have done with my Queſtions, and ſhall ſtick to the firſt Reaſon why the Action of the Sun over the whole Syſtem does not draw the Satellites from their primary Planets; at leaſt till I ſee ſtronger Arguments againſt it.

P. The Condition you add is reaſonable.

M. At the ſame Time though I think it ſhould ſtumble every Body, and they muſt deſpair of ever underſtanding theſe Motions, if the Explication of any *Axiom* ſuſpended the plain and ſelf-evident Truth I mentioned before; or ſhewed that, when two unequal Forces act at once on the ſame Body in

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in contrary Directions, it may yield to the weaker in Oppoſition to the ſtronger.

P. As long as that Truth lies in the Way, it will be the more difficult to aſſign any other Reaſon than we have done, why the *ſecondary Planets* are not carried off from their *Primaries* by the Action of the Sun.——

M. Do you want to be relieved, *Philon?*

P. Very much: You aſk Queſtion after Queſtion without Mercy.

M. I am glad of this Confeſſion: My Imagination is a little fatigued with theſe Niceties, and not ſtrong enough to enter on a new Subject; though I have not half done with the Particulars I deſigned to aſk. Therefore I ſhall be with you again very ſoon.

P. Then we muſt agree for the future how long we are to diſcourſe, and not talk on at your Diſcretion.

M. We may think of that hereafter.

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Matho *desires to know why the Secondary Planets might not have revolved separately about the Sun, as the immediate Center of their Motion? If the Distance of the Satellites from their Primaries had been greater or less, what must the Consequences have been? That there may be more Bodies in the Solar System than are discoverable by us. In what Proportion the centripetal Force is increased or diminished, as the Planet is nearer to, or more remote from the Sun. From what Causes the centrifugal Force becomes greater or less. It is shewn necessary, by bringing the centripetal and centrifugal Forces to an Equilibrium, that the Cubes of the Distances of the Planets from the Sun must be as the Squares of their Periodical Times. And contrarily, as this Proportion holds in fact, from thence it is shewn, that the centri-*

fugal, and therefore the centripetal Force, muſt be inverſely as the Squares of the Planets Diſtances from the Sun.

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CV. *P.* I FIND, *Matho*, you keep your Word punctually; wherefore let us now ſettle how long we are to diſcourſe.

M. I have obſerved, *Philon*, when a Man is every now and then looking at his Watch, to ſee whether the Hour be near, or paſt, his Head is more ſet on what he is to do, than what he is doing: So pray let us begin without any ſuch Condition.

P. You will have every thing your own way.

M. My third Difficulty, as you may remember, was, Why the Secondary Planets ſhould not revolve directly about the Sun, rather than about other Planets, which revolve about him? For there is a Simplicity in all the Works of Nature, though ſtill pregnant with Variety of Effects; ſo that there muſt be ſome weighty Reaſon for this extraordinary Complication, and compounding of circular Motions with circular Motions.

P. It is very true; this could not be done without Choice and Deſign. The *Great Architect of Nature* might have diſpoſed thoſe

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thoſe Bodies in other different manners; but poſſibly in none either more wonderful, or more uſeful. The Power and Knowledge diſplayed raiſes our Wonder, you find, to the greateſt Height; the Mind ſinks under the Variety; for ſtretching to get a full View, it is ſoon forced to ſlacken in the Attempt: And as to the Uſefulneſs, it is ſurely the moſt extenſive we could conceive.

M. I know from Experience how ſoon the Mind is forced to ſlacken; but have no Notion of the extenſive Uſefulneſs of this complex Machination, which is the main thing I want to be informed in.

P. You will diſcover this yourſelf as we go on: In the mean time it is eaſy to perceive thus much of the Deſign. The Sun, as was obſerved before, is the *Fountain of Heat and Light* to the whole Syſtem: Upon this account the Poets ſometimes called him the *Eye of the World*; and for the ſame Reaſon you inferred, that he was to be a Body of exceeding Magnitude and Grandeur, in reſpect of the Planets that roll round him.

M. I do remember it.

P. Yet it was not poſſible that all the Parts of the Syſtem; as well the remoteſt, as thoſe that lie neareſt to him; ſhould

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enjoy this Advantage of his Heat and Light equally.

M. It was not: For as the Center of the Syſtem was the moſt proper Place for diſpenſing theſe with the greateſt Equality, it neceſſarily follows that, while the Diſtance from the Center is increaſed, the Influence of his Rays muſt be leſs perceived.

P. Wherefore, though *Mercury*, which is next to the Sun, and perhaps *Venus* the ſecond from him, ſufficiently enjoy this kindly Influence from his direct Rays; yet our *Earth*, which lies at a greater Diſtance, hath a Moon to attend it: And it is by her throwing back on the Earth his reflected Splendor, that we enjoy the Light of the Sun more ways than one; and our Nights, eſpecially in the Winter Seaſon, borrow a ſecondary ſort of Day from the Orb of the Moon.

M. I have often indeed admired the Difference of the Winter and Summer *full Moons*: When the Nights are long, the full Moon mounts high in the Heavens, and ſheds a ſtrong Light; but in the Summer Months ſhe creeps dimly among the Clouds and Vapours near the Horizon: The Reaſon of which, I think, is not difficult to be found out.

P. It

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P. It is rather neceſſary it ſhould be ſo; but to proceed: As *Jupiter* is much farther removed from the *Focus* of the Syſtem (if we may ſo call the Sun) four Moons roll about him, which, by their quick Revolutions, variouſly illuminate the Hemiſphere of that Planet turned from the Solar Rays, and pleaſantly diverſify his Nights, though otherwiſe remarkably ſhort. For (if we might call the Revolutions of thoſe Satellites by the Name of Months, as we do thoſe of our Moon) ſome of the Months in *Jupiter* are not ſo long as two Days with us, conſiſting of but about forty-two Hours; others of them are leſs than four of our Days, and the longeſt of them, which contains forty of the Days in *Jupiter*, is hardly equal to ſeventeen Days with us. Whence ſome or other of theſe Moons muſt either be in the Oppoſition, and ſhine with full Luſtre, or in the Conjunction, or in the Quadratures, almoſt every night. Beſides, theſe Moons, by their *manifold Eclipſes* (while they frequently dip into the Shadow of their *Primary*, often obſcure the whole Body of the Sun, and ſometimes intercept the Light of one another) afford a moſt entertaining Proſpect, and inſtructive Phænomena to the

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Inhabitants of that Planet, if any ſuch there be.

M. This is really a noble, and (if I may ſo ſay) an expenſive Contrivance for reflecting the Solar Rays on all the Parts of this large Planet: Though he does not enjoy ſo ſtrong a Light as our Earth; yet I perceive he hath a far more delightful Variety of Splendor.

P. This Apparatus, *Matho*, for reflecting the Light on all the Parts of the Primary Planet, is the more curious, if we conſider that at great Diſtances from *Jupiter*'s Equator the lower Moons cannot be ſeen; the Curvature of his Surface intercepting them from the Spectator's Eye: Therefore the other Moons are raiſed above theſe, to give Light (as it would appear) to thoſe in greater Latitudes.

M. That ſeems really to be the Deſign.

CVI. *P.* The Contrivance is ſtill heightened when we come to *Saturn*, the remoteſt of the Planets. He hath five Moons conſtantly rolling round him, which variouſly throw in the borrowed Light of the Sun on his diſtant Orb: And many ſuppoſe, becauſe of the large Interval between the fourth and

fifth, that there is a *ſixth* revolving there; though the Teleſcope has not yet been able to diſcover it. Theſe, eſpecially the four innermoſt, reſemble *Jupiter*'s Moons in the Smallneſs of their Diſtance from their Primary, and Quickneſs of their Revolutions about it: Therefore they diverſify *Saturn*'s Nights (which in all Probability are likewiſe but ſhort) with various and beautiful Appearances of the ſame Nature as in *Jupiter*. But beſides all this, he is ſurrounded with that ſublime and ſtupendous *Arch*, which we mentioned elſewhere; and to which nothing is found equal, or like, in all Nature, ſo far as Mortals hitherto know. What a grand and noble Sight muſt it be, to behold in the Night time, ſuch a lofty reſplendent Arch, riſing from the Horizon on each Side, and ſtretching up to the Heavens; which, as the Diſtance from it increaſes, ſeems the more auguſt and ſtately! This prodigious *Annulus* itſelf probably turns round on its Axis; for it is reaſonable to ſuppoſe that no Body in Nature, fitted for ſuch a Motion, is without it. Thus the Shadow of the interior Planet, which always falls on one of the Sides of this Ring, when the Sun has a Declination to

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either Tropick, muſt ſoon be removed, and the Light of the Sun reſtor'd.

M. Let me aſk you, Does the Plane of this *Ring* fall in with *Saturn*'s Equator?

P. It does.

M. Then I eaſily conceive that the Shadow of *Saturn* muſt be projected on that Side of it, towards which the Sun declines. Pray go on. Theſe Appearances are new and ſingular, as if one were inventing ſomething to amuſe the Fancy.

P. It is not eaſy to reckon up the ſeveral different Appearances which this mighty vaulted Body muſt make to the different Parts of the Planet; or rather to a Spectator there reſiding. At ſome Times of *Saturn*'s Year, and in certain Latitudes from his Equator, it eclipſes the Sun every Noon, as he declines more or leſs to the oppoſite Side. And tho' the Duration of theſe Eclipſes be ſtill varying, yet they can never laſt long, if the diurnal Rotation of the Planet on its Axis be as quick as that of *Jupiter*.

M. Pray how far is the inner Edge of the Ring diſtant from the Body of *Saturn*?

P. About ſix or ſeven times the Semidiameter of our Earth; and they reckon the Ring itſelf to be as broad.

M. Then

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M. Then I conceive, methinks, ſince the Plane of the *Ring* falls in with *Saturn*'s Equator, and ſince there is ſo large a Space open between it and the Body of the Planet, that in ſome Places where it is Winter, and the Sun declines to the oppoſite Tropick, he muſt appear under the *Ring* at Mid-day, ſhining through between it and the Body of the Planet: And contrarily, in Places more remote from the Equator, the upper Part of the Ring muſt eclipſe him at Noon-day: And that theſe *meridian Splendors* and *Eclipſes* muſt ſtill extend farther towards either Pole, the farther the Sun declines to the oppoſite Side. For if the Arch of a Bridge lay South and North, the Light below and Shadow above muſt become ſhorter or longer, as the Sun roſe higher in the Morning, or deſcended lower towards the Weſt in the Evening.

P. This is indeed finely imagined!

M. Since theſe things are ſo, I am entirely for a diurnal Rotation of *Saturn* on his Axis; otherwiſe theſe Eclipſes would laſt, I preſume, for ſome of our Years.—— But pray what can the Deſign of this extraordinary Contrivance be?

P. Alas!

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P. Alas! *Matho*, this is what I am not able to tell you. The greateſt Men have hardly attempted this in Conjecture; and thoſe, who have ventured to make Suppoſitions, have talked rather as if they had been thinking of the Ruins of ſome decayed Fabrick, than the Works of an *Almighty Being*. From all Appearances it ſeems to be a Work ſtill in Repair, and anſwering ſtill the ſame Purpoſe for which it was originally contrived. Thus much only I think we may venture to ſay, That it was originally deſigned for ſome greater Purpoſe than barely to reflect the borrowed Light of the Sun on the Globe it ſurrounds: Since during one half of the Year in *Saturn* it intercepts as much Light, as it reflects the other. And certainly the Purpoſe it ſerves for, whatever that may be, cannot be leſs noble, than the Structure itſelf is ſtrange and ſingular. ——

M. How comes it then, *Philon*, that we ſhould ſo ardently deſire the Knowledge of Things which are without our Reach? Are thoſe Deſires unreaſonable? or is the Accompliſhment of them only impoſſible? If the Deſires themſelves are unreaſonable, why ſhould they be ſo ſtrong? If they are not; why ſhould it be impoſſible to gratify them?

P. You

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P. You aſked this before, as a *Queſtion*, *Matho*; and now you urge it as an *Objection*. In the Purſuit of Knowledge we ſhould proceed by Degrees and with Attention: Every Thing in Time will appear conſiſtent: We cannot diſcover the Reaſons of Things by Precipitance and Impatience. We know not all the Wonders in our own Bodies, and therefore ought to be the leſs impatient, that we know not all Wonders in the Univerſe round us. You inferred perfectly well before, *That we can have no rational Deſires, but what were deſigned to be gratified.* The Methods of Senſe are not accommodated to the finiſhing our Enquiries, or the full Attainment of Knowledge. An Eternity of ſenſitive Life would be the greateſt Miſery to a rational Being, and could never have been propoſed by the Author of the rational Nature. An Eternity of Sloth and Inactivity to an *active Nature* is no leſs abſurd. We are ſo framed as neceſſarily to have interminable Views; but have not enough conſidered what would be the conſiſtent Employment of interminable Exiſtence to a rational and active Being. The Conſideration of theſe Things would carry us a great way, and is foreign to our Purpoſe.

M. You

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M. You affect, I perceive, to talk myſteriouſly; and for all that I underſtand ſo much of what you ſay as gives me Pleaſure: But, to leave a Subject you are unwilling to enter upon at preſent, tell me, ——

CVII. If the remoter Planets had thoſe Moons to attend them, in order to compenſate their Diſtance from the Sun, by reflecting on them his borrowed Splendor; how comes it that *Mars* has none? He is more remote from the Sun than our Earth, which notwithſtanding hath an Attendant to caſt upon it this ſecondary light.

P. We cannot be certain that *Mars* is without a Satellite; the Learned are rather of Opinion that he hath one, though it be not conſpicuous to the Inhabitants of our Globe, becauſe of its Smallneſs: For as *Mars* is one of the leaſt of the Primary Planets, it would be againſt the Order of Nature, if he carried along with him a larger Secondary. And it is the more probable that he is not unattended, becauſe his Diſtance from the *Earth* is greater than the Diſtance of the Earth from *Venus*: And ſome reaſonably ſuppoſe that even *Venus* too hath a Moon attending her. So that if there be

be Room between the Earth and *Venus* for each to have a Satellite, without diſturbing the one the other, there is ſtill more Room between the Earth and *Mars* for this Purpoſe.

M. This Increaſe of Diſtance cannot indeed be for nothing; nor can we imagine that any of the Planets would have been ſet at greater Diſtances from the Heat and Light of the Sun, without a weighty Reaſon.

P. A Satellite of this Planet likewiſe muſt be more difficult to be obſerved, becauſe the *Secondary* of a ſmall *Primary* muſt revolve at a leſs Diſtance from it.

M. If then both *Mars* and *Venus* have Moons attending them, there will be *new Bodies* in our Syſtem.

P. Though as old as the Syſtem itſelf, they muſt be new to us; as *Saturn* and *Jupiter*'s Moons were, which lay hid from the Eyes of Men, through all paſt Ages, and muſt have ſtill remained unknown, had not the happy Invention of the Teleſcope diſcovered them, not very many Years ago.

M. At this rate we cannot be certain that we know all the Bodies of our own Syſtem.

P. Nothing that concerns the Welfare of the Syſtem depends on our Knowledge.

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The Ancients thought they knew all the Bodies of the Syſtem, when they reckoned but eight of ſeventeen which we know. Nevertheleſs concerning this Matter I would have you conceive thus. —— The Solar Syſtem, with reſpect to us the Inhabitants of the Earth, conſiſts of thoſe Bodies which we can perceive: But if a Spectator were to be carried from one part of the Syſtem to another, he would loſe Sight of ſome Bodies that were before conſpicuous to him, and others he knew nothing of before would come in View. Thus were he placed in *Saturn*, he could perceive none of the inferior Planets, except *Jupiter*, which would appear to him ſo to move about the Sun, as *Mercury* appears to do to us; but at a ſomewhat greater Diſtance: *Jupiter*'s greateſt Elongation from the Sun appearing there to be about thirty-ſeven Degrees, and *Mercury*'s here about twenty-eight. As to *Mars*, *Venus*, or our Earth, a Spectator placed in *Saturn* could never know that there were ſuch Bodies in Nature, unleſs he chanced to eſpy them like dark Spots in the Diſk of the Sun, while they paſſed in their retrograde Motion, between that Luminary and his Eye; as we ſometimes perceive *Venus* and *Mercury*. And from

from this accidental View of ſuch *black Points* in the midſt of the Light, he could not in the leaſt conjecture what they were; or that they were Planets carried by the ſame Laws about the Sun, as *Saturn* himſelf is. Yet he would have a *glorious Heaven* over his Head, illuminated with five bright Moons, (or ſix probably) beſides the wonderful *pendulous Arch* we ſpoke of, and the innumerable Hoſt of fixt Stars. The ſurpriſing Phænomena of thoſe nearer Bodies would make him look upon *Saturn* as the moſt delightful Seat in Nature. Nay, when the Spectator had come down ſo far as *Jupiter*, he could even there perceive none of the four inferior Planets, unleſs by the ſame Accident as in *Saturn*, or the Help of better Inventions than have been hitherto diſcovered. If we ſuppoſe him aſſiſted with ſuch Helps, and that he had Skill to make Obſervations, he might ſtill ſee the *Train* he left behind him, but not the noble Appearances they made in the *upper Planet:* But this could not be a Sight for common Eyes, or of daily Uſe.

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M. It muſt be ſo: For, if we may compare ſmall Things with great, the moſt ſtately Fabricks ſhrink into a diminutive and confuſed Appearance, when we are removed

but

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but a few Miles from them; and others we did not formerly attend to grow magnificent and ſtately as we draw near them.

P. That is the very Caſe here: *Jupiter* in the Approach would ſwell immenſely to the Eye, ſo as to make the Grandeur of *Saturn* to be quite forgot; and beſides the *Firmament of fixt Stars* and the ſuperior Planet *Saturn*, the Spectator would here be entertained anights with four refulgent Moons, each appearing much larger than the Sun himſelf; whoſe different *Phaſes*, nimble *Revolutions*, and various, as well as frequent *Eclipſes*, would continually afford him rational Amuſement.

CVIII. *M.* Pray proceed; you carry me on delightfully through the ſeveral Parts of our Planetary World. Methinks I ſee the *Heaven* of *Jupiter*, or *Saturn*, much more beautiful than what we perceive here in a Winter Evening. Theſe radiant Moons, in the Neighbourhood of their *Primaries*, muſt engage a Spectator there more ſtrongly in the Contemplation of Celeſtial Appearances; and in my Opinion make him more eaſily acquainted with the Laws and Principles of theſe Motions, than can be done here with us.

P. I am

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P. I am of the ſame Opinion: For having a compact Syſtem of Planets ſo near at Hand, and reſiding on a larger Body, whoſe Semi-diameter bears a great Proportion to the Diſtances of theſe neighbouring Moons, he would have great Advantages in making Obſervations, and conſequently in diſcovering the fundamental Law of Bodies revolving about a Center, by the Compoſition of a centripetal and projectile Force. —But if we ſuppoſe the Spectator brought down to *Mars*, the Celeſtial Appearances will have quite changed their Face. He would indeed perceive our Earth going before, or following after the Sun, as a Morning or Evening Star, after the ſame Manner as we do *Venus*; though its Elongation from the Sun would not be quite ſo great; and *Venus* would appear to him, as *Mercury* does to us, generally obſcured, to wit, by the Neighbourhood and brighter Rays of the Sun. But for *Mercury*, he could not get a Sight of that Planet, unleſs he eſpied him by Accident as a ſmall black Speck on the Sun's Diſk. And for the like Reaſon the learned *Gregory* ſuppoſes, that we the Inhabitants of the Earth cannot be certain, that there is not another primary

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Planet inferior to *Mercury* himſelf, or between him and the Sun. But the Spectator in *Mars* would ſee the two ſuperior Planets, *Jupiter* and *Saturn*, though without their ſhining Moons. Whence the Nights in this Planet, which are nearly of the ſame Length as ours about the Equinoxes, muſt be more dull and languiſhing than our Nights about that Time, unleſs he be accompanied by a Moon of his own. And as a Spectator *there* could not perceive our Moon with leſs Difficulty than the celebrated *Caſſini* got once or twice a Glimpſe of *that* of *Venus*; ſo it muſt be ſtill more difficult for a Spectator *here* to get a View of his Moon, as being leſs, and rolling at a leſs Diſtance from him. —— Thus you ſee, *Matho*, that the ſame Syſtem muſt appear to conſiſt of very different Bodies, when a Spectator is ſuppoſed to be carried up and down through the ſeveral Parts of it. It is no Argument therefore that Bodies which make for the Symmetry and Order of the Syſtem are wanting, becauſe we do not perceive them: It is rather probable that there are ſeveral Planets, either primary or ſecondary, which the Induſtry of Mortals hath not yet diſcovered; nor perhaps ever will.

Who

Who before *Gallilæo* could have ſuſpected that *Jupiter* had been ſo nobly attended? Or, who would have believed that *Saturn* was accompanied by ſuch a Train of Moons, before *Caſſini* and *Huygens?* It is reaſonable to think that there are no *Chaſms*, or unneceſſary vacant Spaces in the Solar Syſtem. The diſproportionately great Diſtance between the *fourth* and *fifth* of *Saturn*'s Satellites, made the laſt mentioned great Man ſuſpect, that a *ſixth* Satellite revolved in that Space; or (which is more remarkable) that perhaps the uttermoſt Satellite had other Satellites revolving about it. Eighth Conference.

M. That would be more remarkable indeed, and, I think, paſt all Comprehenſion; if a Body revolved about another as its Center, and that other about a third as its Center, and that ſtill about a fourth as its Center, who could conceive this Compoſition of circular Motions!

P. What is hardly to be conceived by us does not therefore become impoſſible to the Divine Power, if the Conveniency of the Work requires it.

M. That is certain. ——

P. All theſe ſixteen Bodies revolve about the Sun almoſt in the ſame Plane; in the

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ſame Plane, namely, that which the Earth moves in: But there are *other*, and thoſe *more numerous Bodies*, which traverſe the Syſtem all Manner of Ways, and which are likewiſe reckoned to belong to it. Hence you may ſee how far we are from being certain how many Bodies belong to our own Syſtem.

M. From what you have ſaid I am ſatisfied: For why ſhould Bodies be conſpicuous to us, for whoſe Uſe they were not originally deſigned?

P. Conſider alſo that, if they were conſpicuous to us, they would not be adapted to the Uſe for which they were originally deſigned: For (as has been ſaid) it is againſt the Order of Nature, that a *Secondary* ſhould be equal, or nearly equal, to its *Primary*.

M. I remember ſtill the *Mill-Stone* revolving about the *Pebble*, and perceive it is mere Unſkilfulneſs to imagine that the Secondaries of other Planets might have been conſpicuous to us. I would gladly know what thoſe *other Bodies* are you mentioned juſt now; but firſt let me aſk,——

CIX. Why is it neceſſary that the Satellite of a ſmall Planet ſhould revolve ſo near it?

P. I expected to have heard the Reaſon of this from you.

M. By this gentle Reprimand I find I have been inattentive to the Conſequences of what has been already ſaid. The Reaſon ſeems to be, that a ſmall Planet muſt have its attractive Force but weak, according to the Quantity of Matter it contains; and the Limit of equal Attraction betwixt it and the Sun at a ſmall Diſtance from it. This will confine its Satellite to a narrow Orbit.

P. Could a Satellite revolve about its Primary at the Extremity of that Limit; or would it in that Caſe be equally, or nearly equally attracted to the central Body, in all Parts of its Orbit?

M. If we could ſuppoſe that the Satellite revolved near, or at this utmoſt Limit; in its oppoſition to the Sun, it would be attracted with more than all the Force of the central Body, the Sun's Action there conſpiring; and in the Conjunction, it would be drawn with no Force at all; the contrary Actions of the Sun and primary Pla-

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net there ſuſpending each other. And this muſt prevent its revolving about a Center in any Manner; as it was in the Suppoſition we made at our laſt Meeting, where the *lower Body* was attracted by *that* above it, as ſtrongly the one Way, as the *parallel Forces* impelled it the other. Whence it appears to me that a Satellite, in Order to revolve about its Primary with tolerable Regularity, muſt be placed a good Way within *this Limit*; that the Inequality of Attraction, in the Oppoſition and Conjunction, (which muſt ſtill be ſomething) may have the leſs ſenſible Effect.

P. What you ſay is ſtrongly confirmed by conſidering the Syſtems of *Saturn* and *Jupiter*. All the Satellites in each of theſe roll at a vaſt Diſtance within the Limits of equal Attraction between the Sun and their Primaries. This is obſervable in their quick Revolutions.

M. I remember you ſaid, the innermoſt of *Jupiter*'s Satellites revolves about him in 42 Hours.

P. And a half.

M. At what Diſtance?

P. At a Diſtance from him nearly as great as our Moon is from the Earth; up-

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on the Suppoſition that the Sun's Diſtance from us is about 21000 Semi-diameters of the Earth.

M. In what Time ſhould it revolve about him at the Limit of equal Attraction?

P. It could not revolve at ſuch a Diſtance, by what you obſerved juſt now: But ſuppoſing it to revolve at 80 Semi-diameters of the Earth within that Limit, it could not finiſh a Period about *Jupiter* in leſs than 700 Days, or near two whole Years.

M. There is a great Difference indeed between 42 Hours and a half, and 700 Days. The Light of it at ſuch a Diſtance muſt be greatly diminiſhed, I preſume.

P. It would appear there perhaps but as a faint Glow-Worm in the Sky, hardly affording the 2900th Part of the Light which it ſhews him at preſent.

M. This is ſuch a Light, I ſuppoſe, as a Candle would give at 2 or 300 Paces in a dark Night.

P. Here is a Figure, *Matho*, of *Jupiter* and his four Moons, at their proportional Diſtances from him; and *this Arch* out here at the Extremity of the Paper,

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ſhews the Limit of equal Attraction between him and the Sun.

M. I ſee it is a vaſt Way without the Orbit of his utmoſt Satellite.

P. It is diſtant from the Center of *Jupiter* about 159 of his Diameters; whereas his utmoſt Satellite is hardly 13 Diameters from his Center.

M. I am not only convinced in Reaſon, but this ſhews me in Fact too, that the ſecondary Planets muſt revolve a conſiderable Way within the Limit of equal Attraction between the Sun and their Primaries, in Order to move with no ſenſible Diſturbance. —— But at what Diſtance might a *Secondary* revolve about *Venus*, or *Mars*, ſince it is ſuppoſed that each of theſe has a Satellite to attend it?

P. It is not ſo eaſy to give a poſitive Anſwer here, as we know not what Proportion the Quantity of Matter in either of theſe Planets bears to that in the Sun; for from the Quantity of Matter and Diſtance given, it is eaſy to determine the Point between any two Bodies, where their attractive Forces will be equal.

M. Yet I ſhould think a probable Conjecture might be made, if we knew the

Magnitude of *Venus* or *Mars*, with Reſpect to the Earth; ſince it ſeems the Proportion between the Quantities of Matter in the Earth and Sun can be aſſigned. Eighth Conference.

P. By that Means perhaps we might come pretty near the Truth.

M. Is *Venus* leſs or bigger than our Earth?

P. Her Diameter is ſomewhat leſs, according to the moſt authentick Obſervations: But as the Bodies nearer the Sun are reckoned more denſe than thoſe farther removed from him, we may ſuppoſe that ſhe contains the ſame Quantity of Matter that the Earth does. And then the Point, where the Sun's Force and hers would ſuſpend each other, muſt fall about 31, 5 Semi-diameters of the Earth from her Center.

M. But a Satellite could not revolve about her at that Diſtance.

P. Nor a good Way nearer, without great Diſturbance from the Inequality of Attractions in the Oppoſition and Conjunction. And though we ſhould ſuppoſe a Satellite to move about her at 22 or 23 Semi-diameter's Diſtance; it could not appear to us farther removed from her than 12 or 13 Minutes: But in all Probability it is placed

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placed much nearer to her. What *Caſſini* ſaw was not above two thirds of *Venus*'s own Diameter diſtant from her; and very ſmall, though well defined.

M. It is no Wonder that ſuch a ſmall Satellite, ſo near its Primary, ſhould eſcape Obſervation.

P. As to *Mars*, the Quantities of Matter in the Earth and him, ſhould be as 5, 6 and 1, according to their Diameters, which are nearly as 8 and 4, 5: But as the Earth is a little denſer, it may be ſuppoſed to contain ſix Times the Matter in *Mars*. And in this Caſe, the Limit of equal Attraction between the Sun and him will be 27 Semi-diameters of the Earth from his Center; ſo that, if we ſuppoſe a Satellite to roll about him at 18 Semi-diameters Diſtance, it could not appear farther diſtant from his Center than ſix Minutes. But if it revolved at 3 or 4 Semi-diameters Diſtance only, which no Body will deny to be poſſible, and is much more probable (if we conſider the innermoſt Satellites of *Jupiter* and *Saturn*,) that it might afford him the greater Light, and perform its Revolutions the ſooner; it could not appear 2 Minutes diſtant from him. Add to this

the

the proportional Smallneſs of ſuch a Satellite, and it will be found almoſt impracticable to diſcover it. Now if it be but only poſſible that, though this Planet had a Satellite, it might not be diſcovered; there is no Reaſon for concluding, becauſe no Satellite is diſcovered, that therefore *Mars* has none: And yet this is the only Argument for that Concluſion.

CX. *M.* I perceive the Strength of your Reaſoning very well, and what Probability there is that *Mars* ſhould rather have a Satellite than be without one. The Conſideration of theſe Things is extremely pleaſant; wherefore let me aſk you, What would be the Conſequence, or what Difference ſhould we feel, if our Moon were removed to twice the preſent Diſtance from us?

P. We ſhould not then have four *ſynodical Months* (as they are called) that is, four Conjunctions of the Moon with the Sun, in the whole Year: Nor ſhould we only be without the pleaſing Variety of ſhorter Months, but the Moon then could not afford us above the fourth Part of the Light we enjoy from her at preſent.

M. That

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M. That would indeed be a very diſadvantageous Change. I have ſometimes read a ſmall Print by the Moon-Shine; but then I imagine the full Moon could not give us more Light than now ſhe does three or four Days after the Conjunction. —— How would Things be if ſhe were carried off from us to four Times the preſent Diſtance?

P. If the Moon were but at twice the preſent Diſtance from us, *Matho*, according to your laſt Queſtion, ſhe could no longer revolve round the Earth as a Satellite; but below it, as an inferior Planet.

M. Well, leaving that Conſideration.

P. If ſhe were at four times the preſent Diſtance from us, we ſhould not have a full Moon once in a Year; nor could ſhe then give us above the 16th Part of the Light ſhe affords us at preſent.

M. That muſt be but a melancholy State, when our Months would be as long as our Year, and our Moon twinkled dimly, like a diſtant Lamp in the Heavens.— But, on the other Hand, what Advantages ſhould we reap if the Moon were but at half the preſent Diſtance from us: For, as removing her to a greater Diſtance, muſt diminiſh her Light, and leſſen the Frequency

cy of its Returns; ſo bringing her nearer us muſt have the contrary Effects.

P. It is ſo; the Months then would be only about a third Part of our preſent Month, and the Moon would give us four times more Light than now: But as the *Tides* are occaſioned by the Action of the Moon upon the Waters; if ſhe were brought within 30 Semi-diameters of the Earth to its Center, the Tides muſt ſwell to a prodigious Height. All the low Countries near the Sea-Coaſts would be rendered uninhabitable, the Sea for many Miles overflowing them every Time the Moon paſſed our Meridian, either above or below. Our Tides, which now riſe to 9 or 10 Feet, would then ſwell to 68, and in many Places to a greater Height. We can ſcarce figure to ourſelves the Impetuoſity of ſuch a Heap of Waters ſetting in ſucceſſively from the Ocean, on the Coaſts, and falling back with equal Fury.

M. I conceive in ſome Sort, what Devaſtation this muſt make: As the Mouths of Rivers are on a Level with the Ocean into which they flow, the Tides would roll far into the Country, and all round muſt be an inhoſpitable Deſert, neither Sea nor dry

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dry Land, but a Scene of conſtant Horror, while the Floods ruſhed either the one Way or the other. How much happier then are we as Things now are! May I aſk you after this, What would be the Conſequence to us, if the Moon's Diſtance were but a fourth Part of what it is; or if ſhe were within ſixty thouſand Miles of our Earth?

P. Perhaps the Tops of the Mountains could hardly then afford a ſafe Retreat to the Inhabitants of the Earth from the tumultuous Sea. I mean it is to be feared, that then the Moon would draw the Ocean almoſt from its Bed, making it wheel round the whole Face of the Globe, in two oppoſite Tumors, or Mountains of Water, as the Earth revolved on its Axis the contrary Way. And if this were to be the Caſe, it nearly coincides with that terrible Diſorder we obſerved before, when we ſuppoſed the firſt Impreſſion of the diurnal Rotation made upon the ſolid Part of the Globe; but not upon the Waters. Perhaps the Mountains themſelves would in Time be daſhed to Pieces, or waſhed down by the Fury of the rolling Floods, and our Planet reduced to a State of Confuſion.

M. I ſee

M. I ſee the Conſequences in both Caſes are nearly the ſame: The not impreſſing the diurnal Rotation on the Waters there, and the Moon's impreſſing a contrary Force upon them here, muſt have had the ſame Effect.

P. It is likewiſe neceſſary here to obſerve, *Matho*, that the Moon, in all Probability, is the largeſt Satellite in the Syſtem, in Compariſon of her Primary; it can therefore leſs bear her nearer Approach. The Satellites of *Jupiter* and *Saturn* are perhaps larger Bodies than the Earth itſelf; but ſtill they are much leſs in Reſpect of their primary Planets. Therefore their nearer Attraction cannot diſorder the Fluids of thoſe Globes. And upon the ſame Account a Satellite of *Mars*, or of *Venus*, muſt be extremely little, compared with its Primary, in Order to roll about thoſe leſſer Planets at a ſmall Diſtance.

M. I was going to aſk you this very Queſtion; namely, What would enſue if the Satellite were equal to its Primary? But you have prevented me. And beſides, thoſe Changes which we think only a Sport of the Fancy to imagine, draw deep, I ſee, in

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in their Conſequences, and affect all Nature round us.

P. The Reflexion is extremely pertinent. —— If the Primary and Satellite were both equal in Magnitude and Denſity, the Diſtinction of *Primary* and *Satellite* would be loſt. If their Diſtance were the ſame as at preſent, their periodical Time ought to be ſhortened, to increaſe their centrifugal Force; if their periodical Time were the ſame, their Diſtance ought to be enlarged to weaken their centripetal. If this were the Caſe between the Earth and our Moon, and if the preſent Proportion were once broke; we have no Notion on what Terms it could be healed again. One Thing however is remarkable in this Suppoſition: That both of them muſt then neceſſarily revolve about their common Center of Gravity, (equally diſtant, in that Caſe, from either): without Room for the Exception I made a little before. Now apply this to the Syſtems of *Saturn*, or *Jupiter*, where there are five or ſix Bodies: All theſe, if equal, ought to be equally diſtant from their common Center of Gravity, and therefore diſpoſed in the Circumference of a Circle; and

and at equal Diſtances from each other in that Circumference. Thus rolling round *that Center*, and keeping ſtill the ſame relative Situations with Reſpect to each other, there would be no Difference of periodical Months, nor Foundation for that Proportion between the Squares of the Times and Cubes of the Diſtances of Bodies moving round a Center; which, if I may ſo ſay, is the Key to all our Knowledge of the Motions of the celeſtial Bodies. Hence taking away the Diſtinction between *Primary* and *Satellite* would be of bad Conſequence in many Reſpects.

M. I find, becauſe we come into a World already prepared and habitable, we are not ſenſible what Art and Power it required to make it ſuch as we ſee it: But from theſe Suppoſitions, and their Conſequences, I perceive how many Ways it was poſſible for a Power and Knowledge leſs than infinite, to have miſcarried in this complicated, mighty Deſign. A mere Change of Diſtance might have made that Moon, which now gently moves the Waters of our Ocean, and chears our Nights, the Ruin of our Globe: And a Change of Magni-

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tude, all Things elſe remaining the ſame, muſt ſoon have ſubverted all Nature.

P. Nothing could better ſhew me, *Matho*, that you have a quick Senſe of the Subjects we diſcourſe upon, than the natural Obſervations you often make concerning them.

M. I am younger than you, *Philon*, and it is more natural for me to make theſe Obſervations, than for the greateſt Philoſopher.

P. What you ſay ſurpriſes me; pray ſhew me how that could be.

M. You Men have forgot your firſt Prejudices, and think always on the right Side: Theſe Wonders therefore do not affect you ſo much. When we come into the World, and firſt begin to turn our Thoughts on the great Objects round us, we fancy the Conſtitution and Frame of Nature muſt be neceſſary: And when we take the firſt View of it, as the Effect of Art and Power, and ſee the Laws obſerved in the Contrivance, we feel the Oppoſition between our Prejudices on the one Side, and the Truth of Things on the other, in all its Force.

P. This ſeems not to be without Reaſon; but it reflects no great Honour on thoſe of

of riper Years, who either never made theſe Obſervations, or have now loſt *that Senſe* of Things which produces them.

CXI. But are you not already fatigued in purſuing theſe Matters?

M. Not in the leaſt; ſomething new always occurs from what we happen to talk upon: And now methinks I ſee the Reaſon why *Jupiter* is placed at ſuch a Diſtance from *Mars*, and *Saturn* from *Jupiter*; as alſo, why the next inferior Planet to *theſe two* ought to have been but ſmall.

P. What do you take to be the Reaſon of all theſe Things?

M. Thoſe two huge Bodies, I ſuppoſe, with their Train of Satellites, muſt by their Attraction have diſturbed each other, had not the Space between them been large enough to prevent that Inconvenience: And had the next inferior Planet been equal to either of them, that muſt have increaſed the Diſorder. What you ſaid a little before ſeems to me extremely reaſonable, *That there can be no Chaſms, nor unneceſſary vacant Spaces in the Syſtem.*

P. Your Conjecture is confirmed by the Obſervation of Aſtronomers; for while

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thoſe two uppermoſt Planets paſs each other, notwithſtanding their great Diſtance, they are obſerved ſomewhat to affect each other's Satellites. And had the Planet next to them (or indeed any of the inferior Planets) been equal to either of theſe, not only the upper Parts of the Syſtem, but the Center itſelf, would have been ſenſible of the Difference. When the Planets happened all to be on one Side of the Sun, and no Balance on the other, *Saturn* muſt have been more diſturbed in his Courſe, and the central Body itſelf ſhaken.

M. Then it ſeems, placing the little Planet *Mars* in the Gap between our Earth and *Jupiter*, as alſo the whole Diſpoſition of the Planets, was not merely arbitrary, and indifferent, as is generally thought, but the Reſult of pre-contrived Order and Convenience.

P. You will perhaps ſee more of this as you go on. When we have weighed Things maturely, and conſidered the Forces of the Sun and Planets, according to the known Laws of Gravitation; we ſhall find that this large Interval, which we may think employed to little Purpoſe, is in the main the greateſt Frugality of Space.

M. You

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M. You ſaid juſt now that, were either of two attracting Bodies made larger, the periodical Time ought to be ſhortened to increaſe the centrifugal Force; or the Diſtance between the two Bodies ought to be widened to weaken the centripetal: Now, though you have already told me ſomething concerning the Law of the centripetal or attracting Force; yet pray reſume the whole Matter, and lead me into it in a familiar way, if poſſible.

P. Good *Matho*, you are like to cut out more Work for us than, I'm afraid, either of us will be able to go through.

M. Enough of your Art, *Philon*, you have already, by your pretended Difficulties, ſcrewed my Curioſity to the greateſt Height.

P. I would do every Thing to oblige you, except ſpoiling a noble Subject, and making it more intricate, through my Want of Ability to communicate it to you eaſily: But ſince it muſt be ſo, let me firſt obſerve to you, that I ſhall be better able to explain theſe Particulars by bringing Examples, than by ſhewing you the Reaſons of them from Nature.

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M. Without apologizing for yourſelf, that is the fitteſt Method to be taken with me.

P. The centripetal Force, you remember, is the immediate Work of the Deity; and though he might have appointed other various Laws according to which Bodies might have gravitated to each other, yet this is the Law which for wiſe Reaſons he has made to obtain, *That the Gravitation between two Bodies ſhould always be inverſely as the Squares of their Diſtances from each other.*

M. This I remember; but let me apply it to the ſeveral Suppoſitions we made before concerning our Moon, that the Thing may become more obvious. —— If the Moon had been at half the preſent Diſtance from the Earth, ſhe muſt have been attracted four Times as ſtrongly by it, as now?

P. Certainly.

M. And then you ſay her periodical Time muſt have been but about a third Part of our preſent Month, in Order to increaſe her centrifugal Force, and prevent her being drawn down to the Earth?

P. It

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P. It is ſo; our Month then would have been to our Month now, as 1 to 2, 828.

M. And her Celerity then muſt have been greater?

P. Without Doubt; as ſhe performed near three Revolutions for one, and but at half the Diſtance.

M. Again, had the Moon been but at a fourth Part the preſent Diſtance from us, ſhe muſt have been attracted ſixteen Times as ſtrongly as now?

P. You are right.

M. And our Month then muſt ſtill have been ſhorter?

P. It muſt have been juſt an eighth Part of our preſent Month.

M. And therefore her Velocity muſt have been greater, to give her more centrifugal Force?

P. Unqueſtionably; for having ſixteen Times more centripetal Force, her centrifugal Force ought to be increaſed equally, to prevent her being brought nearer the Earth.

M. On the other Hand, had the Moon been at twice the preſent Diſtance from the Earth, it muſt have attracted her but with a

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fourth Part of the Force it does now; and we could not have then had four ſynodical Months (as you called them) in the whole Year; or her Celerity muſt have been leſs, to weaken her centrifugal Force, and bring it alſo to be a fourth Part of the former.

P. In all this you are extremely right.

M. And had ſhe been four times farther removed from us, ſhe muſt have been attracted but with a ſixteenth part of the preſent Force; in which Caſe we could not have had a full Moon once in a Year; and her Celerity muſt have been ſo diminiſhed, as to leave her but a ſixteenth part likewiſe of her former centrifugal Force.

P. You remember the Caſe very well, and conclude very rightly.

M. From hence then it follows that, as Change of Diſtance from the attracting Body changes the centripetal Force; ſo changing the Velocity of the revolving Body changes the centrifugal.

P. It muſt of Neceſſity.

M. But as the centripetal Force is increaſed or diminiſhed, inverſely as the Squares of the Diſtances; is not the centrifugal Force alſo increaſed or diminiſhed in a certain regular manner?

P. It

P. It is.

M. Now indeed I call to Mind the Inſtance of the Stone whirled round in a Sling, when you told me that the centrifugal Force was changed in a very regular manner.

P. You call to Mind that Particular very opportunely.

M. Pray then ſhew me after what Proportion it becomes greater or leſs; for I perceive, if we knew that, we might underſtand how it is that the two Forces balance each other; ſo that a Planet is neither drawn down to the central Body, nor flies out from it.

CXII. *P.* Here you muſt know that, though the Law of the centripetal Force be arbitrary, and might have been different from what it is, had it ſo pleaſed the Creator; the centrifugal Force, on the contrary, riſes from a Neceſſity of Nature; or, to expreſs it more juſtly, from the Reſiſtance of Matter, by which a Body always tends to move on in a ſtraight Line.

M. We talk'd of this long ago, when we firſt conſidered the circular Motions of the Planets.

P. Hence therefore a Body muſt reſiſt being put out of its Direction (that is, it muſt

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muſt exert a centrifugal Force) not only according to the Celerity with which it is carried round; but alſo by ſo much the oftner as it is drawn out of its Direction by the centripetal Force in the ſame Time, or hindered from going on in a ſtraight Line.

M. This ſeems plain; it muſt reſiſt each Time it is pulled in, as it were, towards the Center; and if a Body is, by a repeated attractive impulſe, four or five times drawn inward from its projectile Direction, in the ſame Time that another is but once diverted from that Direction, their Celerities being the ſame, it muſt have four or five times the centrifugal Force of the other. However as the centrifugal Force here depends on *two different Cauſes*, pray ſpeak of them ſeparately, that I may the more clearly conceive what Share each has in producing the Effect.

P. With all my Heart. Let us therefore ſuppoſe that another Moon, at a four times greater Diſtance than ours, were carried round the Earth in the ſame Time; and then tell me what Celerity ſhe muſt have, with reſpect to the interior Moon?

M. Four

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M. Four times a greater Celerity; becauſe ſhe moves round a four times larger Circle in the ſame Time.

P. The Periphery of it is certainly four times longer.

M. That is what I meant; for the circular Space itſelf is ſixteen times larger.

P. Therefore as ſhe moves with four times a greater Celerity, ſhe muſt have four times a greater centrifugal Force; for ſhe has four times a ſtronger Tendency to go on in a ſtraight Line.

M. This I think I conceive: and if her Orbit were only twice as wide, ſhe would have but twice the centrifugal Force of the inner Moon, becauſe but twice her Celerity. For I ſuppoſe there are as many Deviations from moving on in a ſtraight Line, in the Circumference of a leſs Circle, as in that of a greater.

P. Certainly; becauſe the leaſt returns back upon itſelf, as well as the greateſt. And if you conceive a Compaſs ſo contrived, as to deſcribe two concentrical Circles at once; like Parts of both Circles require an equal turning round of the Compaſs; and therefore equally deviate from ſtraight Lines.

M. Thus

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M. So far I underſtand then; when two Bodies revolve about a Center in the ſame Time, and there is no Difference except in the Celerity, or Wideneſs of their Orbits, their centrifugal Forces will be as their Celerities. This likewiſe is the Caſe when we ſuppoſe the Earth to revolve about the Sun at a greater, or leſs Diſtance, ſtill in the ſame Time: The centrifugal Force, and therefore the centripetal, is always as the Earth's Celerity in its Orbit, or as its Diſtance from the Sun.

P. The Application is very juſt.——But to come to the *ſecond Cauſe* of the Increaſe of centrifugal Force; ſuppoſe now that more Revolutions of the inner Moon were performed in the ſame Time: and the Reckoning will become different.

M. Give me an Example.

P. If the inner Moon, inſtead of one Revolution, performed two in the ſame Time; what Celerity muſt ſhe have?

M. Twice her former Celerity; that is, half the Celerity of the exterior Moon.

P. And how often would ſhe be retracted from going on in a ſtraight Line, in theſe two Revolutions?

M. Twice

M. Twice as often certainly, as in one Revolution.

P. Join the Effects of theſe two different Cauſes together, and then tell me what her centrifugal Force will be?

M. Give me Time to conſider this,—— In her two Periods ſhe is twice as often retracted from going on in a ſtraight Line, as in one; or twice as often reſiſts being turned out of that Direction; and at each time with double the Force, becauſe with double the Celerity: —— Therefore her centrifugal Force is twice double, or quadruple of what it was.

P. It is juſtly enough reaſoned, *Matho*; but could you not make it a little plainer?

M. I underſtand the Thing, but have not a Command of Words.—Twice the Number of Retractions in the ſame Time will make the Body reſiſt twice as much being put out of its Direction, or exert a double centrifugal Force in the ſame Time; and double the Celerity will make it double of this Double.

P. This will indeed ſhew that in the whole Time of the two Revolutions, the Body exerts a quadruple centrifugal Force, of what it does when it performs but one

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Revolution in that Time: But how will it ſhew that the Body exerts a quadruple centrifugal Force in any Inſtant of that Time?

M. Since the Body moves equally in its Orbit, or does not exert more Force in one Part than another; divide the Time into any Number of Inſtants you pleaſe, and the whole Sum of the centrifugal Force into as many Parts; and ſtill the centrifugal Force in any Inſtant, when the Body performs two Revolutions, will be quadruple the centrifugal Force in the like Inſtant when it performs but one.

P. I perceive now you underſtand the Matter thoroughly; nor is the Argument different on any other Suppoſition: If the inner Moon is carried three times round inſtead of once, ſhe muſt move with thrice the Velocity, and exert her Tendency of going on in a ſtrait Line thrice as often; that is, ſhe muſt exert thrice the triple of her firſt centrifugal Force in the ſame Time: Or her centrifugal Force is now nine times greater than it was.

M. Or if ſhe performed four Revolutions for one, ſhe muſt exert four times as often her centrifugal Tendency, with four times the Celerity; or have four times the Quadruple

druple of her firſt centrifugal Force. So that the centrifugal Force here increaſes with the Squares of the Number of Revolutions performed in the ſame Time. Eighth Conference.

P. That indeed is the Law, reſulting, you ſee, from the Inertia, or Inactivity of Matter.

M. But a Body revolving about another, muſt either be drawn nearer to it, or carried farther from it, unleſs theſe two Forces, the centrifugal and centripetal, balance each other.

P. It muſt.

M. What Method can there be then of bringing them to an Equilibrium; ſince the one Force is *arbitrary*, and the other the *neceſſary Effect* of the Inertia of Matter?

P. A Method of accompliſhing his Deſigns can never be wanting to the Deity: It is from bringing theſe Forces to an Equilibrium, *Matho*, according to the different Diſtances of the Planets from the central Bodies, that the beautiful Proportion flows, which we have ſo often ſpoke of, between the Cubes of the Diſtances, and Squares of the periodick Times.

CXIII. *M.* Since

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CXIII. *M.* Since therefore we have fallen ſo naturally into this Subject, pray take the Trouble to ſhew me how this Proportion reſults from bringing theſe contrary Forces to an Equality: For the Explication ſeems to follow eaſily from what we have already ſaid.

P. It does indeed; nor ſhould I think it a Trouble: But ſeriouſly I am afraid that ſo many new things will be apt to confound each other in your Memory.

M. Their Connexions and Dependance rather will bring them back in Order. Only go on in the ſame plain Method, and by the Help of Examples: This makes the abſtract Reaſoning more palpable, and hence the Things will ſtick better with me.

P. Well, ſince you will have it ſo, let us keep ſtill to our two Moons, the one at four times a greater Diſtance from the Earth than the other; and if both revolved about it in the ſame Time, in what Proportion ſhould their centrifugal Forces be?

M. The centrifugal Force of the more remote, as was ſaid juſt now, muſt be four times greater than that of the *nearer*; as having four times the Celerity, and but once the

the Number of Deviations from the projectile Direction.

P. And in what Proportion ſhould their centripetal Forces be?

M. Stay a little till I recollect.——The centripetal Force becomes greater, as the Square of the Diſtance becomes leſs.—— It is ſo. The centripetal Force of the inner Moon, *Philon*, ſhould be ſixteen times greater than that of the *other*.

P. If then we ſuppoſe that theſe Forces are equal in the exterior Moon, what Difference will there be between them in the *nearer*?

M. Stay a little —— The inner Moon hath ſixteen times a greater centripetal Force, and only the fourth Part of the centrifugal. Bleſs me! How ſoon muſt ſhe be drawn down to the Earth! —— She has only the ſixty-fourth Part of the centrifugal Force which ſhe ought to have, that it may balance the centripetal, and keep her moving in a Circle about the Earth.

P. Explain this Point a little more diſtinctly, if you can.

M. Theſe two Forces are equal in the exterior Moon: But the centripetal Force of the *nearer* is ſixteen times greater than the *one* of them, and the centrifugal Force

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only a fourth Part of the *other*. Wherefore it is plain that this laſt Force muſt be ſixty-four times greater than it is (that is, ſixteen times greater alſo than the centrifugal Force of the exterior Moon) that it may balance its contrary centripetal Force.

P. You have now made it plain enough: But how is her centrifugal Force to be increaſed, that it may become ſixty-four times greater than it is?

M. Give me a little Time to think of it: This is pretty crabbed Work for a Beginner, ——The centrifugal Force is increaſed with the Square of the Number of Revolutions performed in the ſame Time. —— That Square ought to be ſixty-four — Therefore the Number of Revolutions ought to be eight — I'm ſure this is right enough. — Now, *Philon*, if the inner Moon performs eight Revolutions, while the outer Moon performs one, ſhe muſt have her centrifugal Force equal to her centripetal, and neither be drawn down to the Earth, nor carried off from it, but return always in the ſame Track.

P. Notably done, *Matho!* You have behaved like a Hero!

M. I am

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M. I am glad of it; but here a Difficulty ſeems to occur.

P. What is it?

M. If one Revolution of this exterior Moon were only equal to eight Revolutions of ours, ſhe muſt certainly be in Conjunction with the Sun in leſs Time than a Year: And you ſeemed to ſay the contrary when I aſked you, What Difference there would be, if the Moon were at four times the preſent Diſtance from the Earth?

P. There is no Difficulty in this Caſe, *Matho:* For though the *periodical Month* of a Moon at four times the Diſtance of ours ſhould conſiſt of about 218 Days; yet 327 Days more ought to paſs, before ſhe could again overtake the Sun, or get between the Earth and him. Becauſe the Earth in the Interim muſt have moved a great way forward in its annual Courſe round the Sun: And it would not be enough for the Moon to come oppoſite to the Point where the laſt Conjunction happened; ſhe muſt ſtill move forward, 'till ſhe get between the Earth and Sun again. Here her *ſynodical Month* therefore ſhould be more than twice as long as her *periodical*; and conſiſting of about 545

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Days, two Lunations would hardly happen in three Years.

M. I have ſome Notion of this: The *periodical* and *ſynodical* Month would always be equal, if the Earth ſtood ſtill: But as the Earth moves, the Moon has ſo much more to run over, after her periodical Month is finiſhed.

P. It is ſo; and at preſent the *ſynodical Month* is about two Days longer than the *periodical.*

M. Well, to return;

CXIV. Let me conſider what I have done, or how the Proportion between the Squares of the periodick Times and Cubes of the Diſtances appears from this Number of Revolutions.

P. You ſee the Diſtance of the interior Moon is 1, and of the *exterior* 4.

M. Right.

P. The Cubes of theſe are 1, and 64.

M. They are.

P. The periodick time of the interior Moon is 1, and of the *exterior* 8.

M. Certainly; ſince the one is eight times the other.

P. But

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P. But the Squares of theſe are likewiſe 1 and 64.

M. O *Philon!* You have made me happy! For it was the Height of all my Wiſhes (if I may ſay ſo) to underſtand this; and now I do underſtand it. This is not only an Example of the Proportion; but it ſhews from the Nature of Things, how theſe Motions muſt be in this Proportion.

P. This is the Law, *Matho*, which obtains in the Motions of all the Primary Planets round the Sun; and alſo in the Motions of all the *Secondaries* round *the ſame Primary.*

M. I remember you told me that they who placed the Earth in the Center of the Syſtem, and ſuppoſed the Sun to revolve about it, in the fourth Place (namely, above the Moon, *Mercury* and *Venus)* confounded this beautiful Law of the planetary Motions.

P. They do Violence to Nature itſelf; ſince the centrifugal Force, or the Reſiſtance of Matter on which it depends, is ſtubborn and unyielding: For, let us ſuppoſe that the Diſtance of the Sun from us was but 12000 Semi-diameters of the Earth, or 200 times the Diſtance of the Moon; and then

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the Cubes of their Diſtances will be 8000000 and 1: The Square-Roots of which Numbers are 2828 and 1. So that the periodical Time of the Sun ought to be 2828 times that of the Moon; That is, either our preſent Year ought to contain 2828 Revolutions of the Moon, each conſiſting of about three Hours, ſix Minutes; or our preſent periodical Month ought to be but the 2828th Part of the Year; whence one Revolution of the Sun would be equal to 211 of our preſent Years. Either of which is monſtrous.

M. Thoſe Philoſophers are as far wrong in this Reſpect, it ſeems, as in ſuppoſing that ſuch a ſmall Body as the Earth could reſiſt the attractive Force of the Sun and Planets, without being drawn from its Place.

P. They might eaſily be excuſed, *Matho*, in not diſcovering this Law of the celeſtial Motions; but not to own the Miſtake they were under, after it was diſcovered, is ſomething worſe than Ignorance.

M. Pray give me another Example of this Proportion, that I may apply the ſame Reaſoning to Bodies revolving at other Diſtances.

P. Suppoſe

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P. Suppoſe two Planets revolving about the Sun, the one 5 times more remote from him than the other, which is nearly the Caſe between *Jupiter* and our Earth; and then —

M. Permit me to go on with the Argument my ſelf. — The Earth, being but at a fifth Part the Diſtance, will have 25 times more centripetal Force than *Jupiter*; and, if they had performed their Revolutions in the ſame Time, it muſt have had but a fifth Part his centrifugal Force. Therefore, if we ſuppoſe theſe two Forces to balance each other in *Jupiter*; when the Earth has got five times more centrifugal Force than it hath, it will ſtill have but the centrifugal Force in *Jupiter*, or the 25th Part of what it ſhould have, that its centrifugal Force, as well as centripetal, may be 25 times that in *Jupiter*, and conſequently the one balance the other.

P. You expreſs the Matter very clearly: Go on.

M. Since the Earth muſt have 125 times more centrifugal Force than it has, that Number 125 muſt be the Square of the Number of Revolutions which it performs in the ſame Time that *Jupiter* performs one;

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or it muſt perform ſome more than eleven Revolutions for *Jupiter*'s one; for 121 is the Square of 11.

P. The Square-Root of 125 is 11, and about two tenths.

M. Then the Diſtances being 1 and 5, the Cubes of theſe are 1 and 125; and the Times being 1 and 11,2; the Squares of theſe are likewiſe 1 and 125.

P. All this is perfectly right, *Matho*; and on this Suppoſition you ſee *Jupiter*'s periodic Time muſt be ſome more than eleven Years: But had we taken the Proportion of the two Diſtances more exactly, which is ſomewhat greater than that of 5 to 1, *Jupiter*'s periodical Time would have been 11 Years and about 314 Days, which it really is. However it was needleſs to have affected ſuch Nicety, which muſt have engaged you in a more tedious Computation; ſince the Reaſon of the Thing appears as well from one Diſtance as another.

M. As this Proportion holds in the Motions of all the Planets revolving about the Sun, I ſhall try the Computation by my ſelf; ſince I have their Diſtances and periodical Times in the firſt Diagram you gave me.

P. By

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P. By that Means you may make this fundamental Theorem familiar to your ſelf.

M. As to its being *fundamental* I am not yet ſo good a Judge: But certainly it is an amazing Inſtance of the Power and Wiſdom of the Creator, to impreſs theſe different Forces on the ſame Bodies in ſuch a Manner, that while the *centripetal* always impells the Planets inverſely as the Squares of their Diſtances from the central Body; the *centrifugal* is proportioned to it in that only Quantity, by which a circular Orbit could be deſcribed!

P. Let thoſe Perſons, *Matho*, look to theſe Motions of the Sun, Moon, and Planets, who ſuppoſe that the *Deity* muſt be an indolent and ſlothful Being; or perhaps only a mere Name, and State-Trick of the firſt Legiſlators, to fright Men into a Compliance with their Schemes.

M. O ſtrange! *Indolent*, or a *mere Name!* What Proof of *almighty Power* would they have; or could they comprehend? Are not theſe Motions expoſed to the Eyes of all? Or would it ſatisfy them that there were an *all-powerful Being*, who preſerved the World, if the heavenly Motions were ſtopt, and Nature went into Confuſion?

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P. You have Reaſon to aſk this contradictory Queſtion: For when Men refuſe their Aſſent to the moſt plain and natural Proofs, it looks as if they would be ſatisfied with their Contraries; that is, with no Proof at all; or rather that they are reſolved not to be ſatisfied.

CXV. *M.* Since it is certain from *Obſervation*, that the Squares of the Times of the Planets round the Sun are as the Cubes of their Diſtances from him; and ſince you have ſhewn me according to what Law the centrifugal Force is increaſed or diminiſhed; I now ſee plainly, and any body may from thence gather, that their Attraction toward the Sun is inverſely as the Squares of their Diſtances from him.

P. Shew me how you collect this?

M. The centrifugal and centripetal Force of any Body deſcribing a circular Orbit about another, muſt be equal: But by examining the centrifugal Forces of any two Bodies, according to the Rules you have explained to me, I find theſe are inverſely as the Squares of the Diſtances of the two Bodies from the central Body. Therefore I conclude, their centripetal

centripetal Forces, which are equal to theſe, muſt be in the ſame Proportion. Eighth Conference.

P. Your Argument is good; but apply it to ſome of our former Examples.

M. In the Example of our two Moons, one at a four times greater Diſtance from the Earth than the other, the nearer Moon hath double Celerity, and deviates eight times oftener from the projectile Direction in the ſame Time, than the *exterior:* Hence ſhe muſt have ſixteen times more centrifugal Force, and therefore ſixteen times more *centripetal*, than the Moon at four times the Diſtance. And from this I now ſee that the Proportion between the Squares of the Times and Cubes of their Diſtances is indeed a *fundamental Article* in order to underſtand the Law of the Planetary Motions.

P. It is as you ſay; from that once diſcovered the reſt becomes eaſy.

M. I am likewiſe ſatisfied from this Argument, *viz.* Since the Squares of the periodical Times of Satellites revolving about the ſame *Primary*, are as the Cubes of their Diſtances from it; that they cannot be more, nor ſo much attracted to any other Center, as to that of the Planet about which they move. For if they were but equally attracted

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tracted to another Point, their Attraction to that Center would be nothing at all, inſtead of being inverſely as the Squares of their Diſtances: Whence that Proportion muſt be ſpoiled.

P. You are right: ſince *no Attraction at all* could have given Foundation *to no Proportion at all.* —

M. But you ſaid that other Laws of Attraction might have been appointed by the *Creator*, had he ſo pleaſed.

P. Surely; for the Attraction might have been directly as the Diſtances, or inverſely as the Diſtances; or directly as the Square-Roots of the Diſtances, or inverſely as the Square-Roots of the Diſtances; with an endleſs Number of other Suppoſitions, which were all equally poſſible to the Deity, though not equally convenient for the Nature of his Work.

M. Pray give me an Example of this, that I may ſee the Difference between any of theſe, and our preſent Conſtitution?

P. You need only to be put in the Way, to purſue any of theſe Caſes by your ſelf. Tell me then, if the Attraction had been directly as the Diſtances, and one Planet had been removed to twice the Diſtance of another

ther from the Sun, in what Proportion would their centripetal Forces have been? Eighth Conference.

M. That at twice the Diſtance muſt have been twice as ſtrongly attracted; according to its double Diſtance, to wit.

P. And their centrifugal Forces?

M. Theſe muſt have been in the ſame Proportion, to balance their contrary centripetal Forces; if they were both to move in circular Orbits.

P. By what Means could the Planet at double the Diſtance have had double the centrifugal Force, to balance its double centripetal Force?

M. If it had performed a Revolution in the ſame Time, its double Celerity muſt have given it a double centrifugal Force. For on this Suppoſition the centrifugal, as well as centripetal Forces muſt have been as the Diſtances. And — at this Rate — all the Planets muſt have revolved about the Sun in the ſame Time: For then their centrifugal Forces muſt all have been as their Celerities, or Diſtances from the Sun.

P. It is ſo; the outermoſt *Saturn* muſt have performed a Revolution, as ſoon as the innermoſt *Mercury*.

M. Let

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M. Let me go on; I think I ſee ſtill ſomething farther. In that Caſe they could never have changed their relative Situation with Reſpect to each other; *Saturn* or *Jupiter* performing half, or any Part of a Revolution, as ſoon as *Venus* or *Mercury*. And if at the Beginning of their Motions, ſome Bodies had been placed on the oppoſite Side of the Sun, with Reſpect to others, they could never have had Sight of each other, but always remained in that Oppoſition, obſcured by the Sun's Rays. Or had an interior Planet been placed directly between another and the Sun, it muſt ſtill have appeared as a Spot upon his Diſk. In ſhort, our preſent Conſtitution ſeems every Way preferable to this.

P. It is likewiſe more natural, *Matho*, that the Attraction ſhould go on decreaſing from the Sun, as well as the Heat and Light, and decreaſing in the ſame Proportion; rather than increaſing. —— Again, If the Gravitation to the Sun had been inverſely as the Diſtances, what muſt have been the Conſequence?

M. A Body at half the Diſtance muſt have been doubly attracted, and ought therefore to have had double the centrifugal Force of another at the whole Diſtance.

P. And

P. And if they had performed their Revolutions in the ſame Time?

M. The innermoſt could have had but half the centrifugal Force of the other; or one fourth of what it ſhould have had.

P. How could it have got four times as much centrifugal Force?

M. If it had performed two Revolutions for one. And from this I ſee the reſt: For ſince the interior Orbit was half the exterior, and the interior Planet revolved twice in the Time the *exterior* revolved once, their Celerities muſt have been equal, and therefore their periodical Times directly as their Diſtances from the Sun.

P. You are perfectly right. If this had been the Law of Gravitation in our Syſtem, the Celerities of all the Planets muſt have been equal, and their periodical Times as their Diſtances. *Jupiter* muſt have performed a Revolution in ſome more than five Years, and *Saturn* in ſomething leſs than ten.

M. I am delighted with this ſort of Reaſoning, and fancy, without giving you more Trouble, I ſhall be able on any other Suppoſition to draw the Conſequences for my ſelf, and find out on what Terms the

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centripetal and centrifugal Forces are to be brought to an Equilibrium, ſo that the Body ſhould deſcribe a circular Orbit.

P. It will not be difficult.

CXVI. *M.* I now begin to underſtand what I deſired to be informed of in the beginning of our Diſcourſe; namely, That all theſe ſixteen Bodies could not have revolved about the Sun immediately, as the Center of their Motion, without great Inconvenience.

P. In what Reſpect?

M. The more remote Planets muſt then have been deprived of their Moons, which, by reverberating the Sun's Rays upon them, diverſify and chear their Nights.

P. They would likewiſe have ſuffered another Loſs, *Matho*, not inferior to this, in that the exterior Planets muſt have been removed to a much greater Diſtance from the Sun.

M. I have a Notion why this muſt have been; but pray aſſiſt me.

P. Our Moon, for Inſtance, by revolving about the Earth, as a Center, muſt neceſſarily be brought near it, that ſhe may be within the Bounds of its ſtronger Attraction: But had ſhe revolved directly about the Sun, ſhe

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ſhe muſt as neceſſarily have been removed to a great Diſtance from the Earth, that ſhe might have been on the other Side of that Limit; leſt the prevalent Attraction of the Earth ſhould have diſturbed her Motion, or drawn her the contrary Way.

M. This is indeed very obvious from what has been ſaid before: She muſt have then rolled a conſiderable Way without that Limit, as now ſhe moves within it.

P. If then we conſider *Jupiter* and *Saturn*, thoſe larger Planets, attended each with a Syſtem of Satellites; their Moons, in this Caſe revolving ſeparately about the Sun, muſt have been removed to a vaſt Diſtance from them.

M. To a vaſt Diſtance certainly, if (which ſeems reaſonable) they ought to have been placed as far without the ſtrong Force of theſe huge Bodies, as now they are within it. For in thoſe remote Regions, where the Sun's attractive Power becomes comparatively weak, the Force of *Jupiter* and *Saturn* reigns far and wide.

P. We may in ſome meaſure gueſs to what a Diſtance their Satellites ought to have been removed from ſuch huge Bodies, in that Caſe; when we conſider that they

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diſturb each other's Satellites at an immenſe Interval in the preſent Diſpoſition.

M. That I did not think of: I find now you had good Reaſon to ſay, *That the large Interval, which we may think laid out to little Purpoſe, is notwithſtanding, when maturely conſidered, the greateſt Frugality of Space.* Any of the Satellites of theſe great Bodies muſt then have been as far removed from either of them, as now the Bodies themſelves are diſtant from each other.

P. If therefore all the Planets, as well Secondary as Primary, had revolved about the Sun ſeparately, as the immediate Center of their Motion, *Saturn*, you ſee, muſt have been removed much farther from the Center than at preſent, and the Bounds of the whole Syſtem greatly enlarged.

M. To near double, I preſume; and the periodical Times of the Planets muſt in Conſequence have alſo been lengthened, according to the Proportion we have ſpoke of.

P. Without doubt: Had *Saturn* been at double the Diſtance, he could not have completed his Revolution in leſs than eighty-two Years.

M. Hence

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M. Hence I ſee then, if all theſe ſixteen Bodies had revolved ſeparately about the ſame common Center, as now the Primary Planets do; they muſt have ſuffered two Loſſes equally great; having the Heat and Light of the Sun more faint and languid by Day, and no vicarious Luminary to ſupply his Place by Night.

P. All that Variety of Light, *Matho*, we ſo much admired before, all thoſe Viciſſitudes, and glorious Phænomena in the Heavens, are quite extinguiſhed on this Suppoſition.

M. In Truth I think it is hardly poſſible to conſider the preſent Diſpoſition of the Syſtem, and how uſeful the ſeveral Bodies in it are to each other, without being full of a Senſe of Love and Gratitude to the Creator, for his indulgent Care and Proviſion. Were we deprived but of our Moon, it would not be eaſy, I believe, to find out all at once the ſeveral Loſſes we ſhould ſuffer.

P. It is reaſonable to think, we could only diſcover ſome of them by feeling them.

CXVII. *M.* What we have ſaid juſt now ſuggeſts a Reaſon, I think, Why the

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uttermoſt Planets ought to have been larger than thoſe nearer the Sun.

P. For what Reaſon then doth it appear to you that this was ſo ordered?

M. By how much the exterior Planets were to be more diſtant from the Sun, ſo much the more were they to ſtand in need of the Relief and Comfort of thoſe Satellites, or vicarious Luminaries: And had they not been prodigiouſly large Bodies, in reſpect of the interior Planets, their attractive Force could not have been ſtrong enough to keep each of them a Syſtem of Moons rolling about it ſelf.

P. I am entirely of your Opinion. *Saturn* we ſee, in the utmoſt Regions of the Syſtem, is able to retain five or ſix ſecondary Lights rolling round him; and *Jupiter*, though near about the middle of it, keeps four: Whereas had any of the four lower Planets been ſet off to the utmoſt Parts of the Syſtem, they could hardly have retained one Satellite, againſt the Attraction of *all the great Bodies* lying near the Center. We may imagine that great Bodies placed near the Center might have been more proper and uſeful; but we do not conſider the Inconvenience of ſuch a Diſpoſition. The Syſtem

in

in that Caſe could not have conſiſted of near ſo many Bodies, nor thoſe near ſo uſeful to one another.

M. Beſides the Inconvenience, the preſent Order ſeems more agreeable and decent. It would have had the Appearance, in ſome ſort, of Neglect and Careleſſneſs, had the leſſer Planets been thrown to the out-ſide: But theſe larger Bodies incloſing the Syſtem look ſtately and magnificent.

P. Add to this likewiſe, *Matho*, (ſince the Celerities of the Planets are reciprocally in the ſub-duplicate Ratio of their Diſtances from the Sun;) that it muſt have appeared againſt the Order of Nature for ſuch a mighty Body as *Jupiter* to have been carried round with the rapid Motion of *Mercury*; or that *Mercury*, *Venus*, or our Earth, ſhould have moved at the ſlow Rate of *Saturn* or *Jupiter*.

M. It does not indeed ſeem natural for a Body to move the faſter, the larger it is: But explain a little, if you pleaſe, this Proportion of the Celerities of the Planets.

P. I dare ſay, if you conſider it, you will be able to make this out by yourſelf.

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M. The Truth is, I do not underſtand what you mean, by being *reciprocally in the ſub-duplicate Ratio of the Diſtances.*

P. That is only, that the Celerities of the Planets are inverſely as the Square-Roots of their Diſtances from the Sun.

M. This is more intelligible, and now I fancy I can deal with it, by the Help of our former Example of the two Moons. —— The *interior* had her Orbit but a fourth Part of that of the *exterior*, and ſhe performed 8 Revolutions for the other's one; ſo that her Celerity was double that of the other: Or their Celerities were as 2 and 1. But 2, the Velocity of the *nearer*, is the Square-Root of 4, the Diſtance of the *more remote*, that is, their Velocities were inverſely as the Square-Roots of their Diſtances.

P. I find I was in the wrong, *Matho*, to affect ſuch a learned way of Speaking; Good Senſe has not fair Play, when it is oppreſſed with hard Words: But I ſhall be on my Guard for the future.

M. If then the Diſtances of the Earth and *Jupiter* from the Sun were as 1 and 5, their Celerities would be contrarily as the Square-Roots of 5 and 1.

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P. You are perfectly right; and it is ſo in all other Caſes. ——

M. Leaving this, pray let me obſerve to you, leſt I forget it, one ſingular Advantage with reſpect to the ſhortening the Darkneſs of our Nights here on this Planet, which I have often thought of by my ſelf.

P. What is it?

M. I underſtand from what we ſaid formerly, concerning the annual and diurnal Motions of the Earth, that we are exactly half the Time in the Rays of the Sun, and the other half in the Shade of the Earth: And yet a great deal more than the half of our Time is Day-Light, if I may ſo expreſs it; for if we take in our *Morning-Dawn*, and *Evening-Twilight*, they ſhorten the dark Half of our Time, by at leaſt three Hours every Night.

P. This, among many others, is an Advantage we reap, *Matho*, from the Conſtitution of our *Atmoſphere*, which ſpread round the whole Earth, does the Office of a Moon for ſome Hours every Night, by reflecting the Light of the Sun in upon the Globe it ſurrounds. Were it not for this Contrivance, intenſe Darkneſs would ſucceed to the Sun-Light, not gradually as now, but in an In-

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ſtant: And contrarily, the Light of the Sun to intenſe Darkneſs. The Traveller would be benighted in a Moment after loſing Sight of the Sun: Nor in the Morning ſhould we be able to bear the ſudden Change from thick Shades to bright Sun-ſhine. It would be like bringing a Man from Confinement in a dark Dungeon, all of a ſudden into open Day.

M. O the Goodneſs of the *Creator!* As Light is a precious Thing, how many wonderful Ways has he taken to ſupply it to his Creatures! Who of a thouſand thinks now on this Advantage? It ſeems to be one of thoſe Caſes, where we could only diſcover our Loſs by feeling it.

P. We are graciouſly prevented with the Comforts of Life; and therefore, as you obſerved a little before, we imagine Things could not have been otherwiſe than they are.

M. I remember you told me before that our Atmoſphere is *a Scene of Wonders*; and I think this is one, *That the Air ſhould be ſo tranſparent and pure, as to tranſmit to us the Light of the fixt Stars; and yet ſo groſs* (if I may uſe that Word) *as to reflect on us the Light of the Sun when abſent.*

P. The

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P. The Air that ſurrounds our Globe, *Matho*, is as neceſſary to our Support, as the Globe itſelf. This elaſtick Fluid is to us the Breath of Life: It is in all the Parts of our Bodies, and by a Counter-Preſſure which we feel not, preſerves them conſtantly from being cruſh'd: It is many Ways abſolutely neceſſary to Vegetation; the Vehicle by which Dews and refreſhing Showers are conveyed to the otherwiſe barren and thirſty Mold; and with all this it is the very Spirit of Fire and Flame, without the Uſe of which Life would be miſerable.

M. I ſee on every Hand by what Inſtances of Power and Kindneſs the Creator hath guarded his Works againſt the Exceptions of ignorant Mortals: All this is performed by Means of an Element, which we think ſcarce deſerves our Attention.

P. It is true; but in the Nature of Things there is no guarding the Works of Knowledge againſt the Calumnies of Ignorance, ſince the more artful the Performance is, the more ſuch People carp at what they do not underſtand. Let us leave them then to the Reproaches of their own Mind, to which a ſmall Acquaintance with the Works of Nature will expoſe them. —

M. I was

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M. I was going to aſk you about the Elaſticity of the Air, and why you think it is in every Part of our Bodies; but I am afraid of troubling you.

P. A few plain Experiments will make you know more of the Elaſticity of the Air, than I can tell you. The Weight of the Atmoſphere is balanced by this Repellency between its leaſt Parts. The Preſſure of it therefore upon all the Parts of our Bodies, is counter-poiſed by this Repellency of the Particles in all Parts of the Body; and not at all by our ſoft Fleſh, and leſs by the Repellency of the outward Particles, one againſt another; becauſe the Surfaces or Figures of our Bodies are not fitted to that Purpoſe. When the Preſſure is taken off one Part of the Hand, by laying it on the Mouth of a Glaſs out of which the Air is drawn, we feel a great Force and Pain. This is becauſe the internal Particles have nothing to act againſt. We ſhould feel an equal Pain at all Times, and in all Parts of our Bodies, were it not for theſe: The Repellency of the external Air has no Share in this. When the Glaſs from which the Air is drawn out, is of an irregular Figure, it is ſhivered to Pieces

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Pieces in an Inſtant *. When Men dive to ſuch Depths in the Sea, that the internal Particles of Air are crowded into half the Room, they feel great Pain. This is confirmed likewiſe from what happens in the Diving-Bell: But theſe Things would require more Time and Words.

M. Nay, *Philon*, I am now more than content to leave you: You talk away ſo faſt, that you are quite out of my Sight.

* When the Air is exhauſted out of the *Glaſs Receiver*, there is a prodigious Preſſure on all the Parts of it quite round. The mutual Repulſe between the Particles of the external Air does not keep off this Preſſure, or form an artificial Vault to preſerve the Glaſs. It bears this Preſſure by the Advantage of its Figure; as an Egg, preſſed equally at both Ends, bears a great Force. Our Bodies therefore ſuffer a Preſſure at all times equal to what the exhauſted Receiver does. And neither the Figure of our Bodies, which is conſtantly changing while we move, or breathe, nor the firm Texture of our Fleſh, is fitted to bear this conſtant and vaſt Weight. And though either of theſe were the Cauſe, we ſhould nevertheleſs feel always an exceſſive Pain. It muſt be a Spring therefore, both more powerful and artful, which counter-acts this Preſſure, and prevents the fatal Effects it would otherwiſe have. And this Spring can be nothing but the Particles of the Air it ſelf in all Parts of our Bodies, as was ſaid. It is impoſſible to reflect on this without Amazement!

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What muſt have been the Conſequences if the Moon had moved in a Plane croſſing the Ecliptick, or Plane of the Earth's Orbit, at right Angles. That our Earth is a Moon to its own Satellite, appearing to her near 16 *Times larger than the Sun himſelf, and thereby throwing on her a vaſt Gleam of Light.* Jupiter *appears to the innermoſt of his Satellites* 1600 *Times larger than the Sun does to us; and* Saturn *more than a* 1000 *Times larger to his neareſt Satellites: They muſt therefore throw a prodigious Splendor on their own Moons. That the Planets both Primary and Secondary are thus carefully illuminated, ſhews they are not empty Seats; but deſigned for Habitation: For* Light, *in the Nature of Things, anſwers to* Eyes. *A ſkilful Artiſt could not deſign that which is more noble for the Uſe*

of what is of an inferior Nature. The whole material Univerſe was therefore made for the Sake of Rational Beings. That our Sun at the Diſtance of Sirius *or* Arcturus *would appear but like one of the fixed Stars, and the ſolar Planets be quite abſorbed by the immenſe intervening Space. The great centrifugal Force on the larger Planets a Relief to their Inhabitants, as ſuſpending a conſiderable Part of their Weight on theſe vaſt Bodies. The Denſity of thoſe great Bodies wiſely contrived in being leſs than in ſmaller Bodies, upon this Account. An eaſy Way to calculate their Quantities of Matter and Denſities.*

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CXVIII. *P.* YOU muſt have grown familiar with the Planets and their Satellites, *Matho*, if you have paſt all your Time, ſince I ſaw you laſt, in the Regions above.

M. Sometimes above, and ſometimes below; but Familiarity, you know, is not ſo ſoon contracted in a ſtrange Country: Beſides, you may eaſily gueſs from the Heads of our laſt Conference, that my Buſineſs in thoſe Places was both various and difficult.

P. All

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P. All is well now, I hope?

M. All is ſo far well, that I have a tolerable Notion of what we were then upon: But other Things ſtill occur which puzzle me.

P. It muſt be ſo with Beginners, till they have gone through the whole Scheme, and ſee the Conſiſtency of one Part with another. But what are thoſe Particulars that puzzled you moſt?

M. Before we ſpeak of any Thing elſe, I muſt acquaint you, that an Expreſſion you dropt at our laſt Meeting has exerciſed my Thoughts ever ſince.

P. What was it?

M. When we had obſerved, that the ſhortening the Diſtance between the Sun and Planets ſeemed by all Means poſſible to have been ſtudied by the great *Architect of Nature*, and had talk'd of the Number of Bodies that compoſe the Solar Syſtem, you added, that all the Planets revolved about the Sun nearly in the ſame Plane; but that there were other Bodies, more in Number, which traverſed the Syſtem all Manner of Ways. This, as I thought, you ſeemed to ſay, with a View to prevent an Objection, namely, Why the Sun might not

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not have been beneficial to more Bodies, which might have revolved about him croſswiſe, or in a Plane croſſing the other at right Angles? This brought to my Remembrance a Particular you hinted at long agoe, when you ſeemed to conclude (from the Motion, I ſuppoſe, of ſome particular Bodies,) that the Attraction of the Sun reached a great Way into the Regions above *Saturn*, or between his Orbit and the fixed Stars. You awakened my Curioſity then, and have never ſatisfied me ſince; wherefore I beg you would inform me, what lies concealed under thoſe diſtant Hints.

P. When I have told you all I know concerning theſe Things, you will hardly think it worth your While.

M. But pray acquaint me with it, whatever it be.

P. If there be any Thing elſe you would diſcourſe of, let us ſpeak of that; and I ſhall readily inform of what I know about thoſe Matters, if an Opportunity ſhould offer naturally.

M. Next then, with Reſpect to the Planets lying all in the ſame Plane nearly, (namely, that of our Ecliptick) I was trying to find what would have been the Conſequences,

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ſequences, if the Orbit of our Moon, for Inſtance, had lain in a Plane croſſing the Plane of the Earth's Orbit at right Angles: But I could neither imagine the Caſe exactly, nor find out a Reaſon why it might not have been ſo in Fact.

P. It is enough in ſuch Caſes, *Matho*, that we ſee the preſent Diſpoſition wiſe and regular; nor are we to imagine that we can come at the Knowledge of, or diſcover all the Reaſons why Things were ordered ſo. *That*, as we have obſerved, may lead us into fatal Miſtakes.

M. I remember well enough the impious Notion, That one might have taught the Deity how to mend his Work.

P. We plainly ſee great Inconveniencies from ſome Diſpoſitions, differing from the preſent, that were equally poſſible: This ſhews us the Kindneſs and Wiſdom of the Creator, in the preſent Order and Motions of the heavenly Bodies. But ſuppoſing other Diſpoſitions might, in ſome Reſpects, have been equally advantageous for us; What then? We have nothing either to complain of, or carp at, becauſe the Deity hath choſen one of two Ways which were equally proper. And yet in the preſent Caſe,

Caſe, it is certainly more orderly and beautiful, that all the Bodies in the Syſtem ſhould lie in the ſame Plane, and move the ſame Way (according to the Order of the Signs) as it were in concentrical Circles; than that their Orbits ſhould have lain acroſs each other, and taken up the whole Space; though we ſhould not know for what other Purpoſe the Creator may have reſerved it free. Ninth Conference.

M. All this I agree to: Yet there is no Harm in endeavouring to conceive what Appearances would have been, had the Planes of the Moon and Earth's Orbits been at right Angles to each other.

CXIX. *P.* That might have been many different Ways. Had the common Section of the two Planes always paſſed through the Center of the Sun, the Moon would then indeed in every Revolution have been in Conjunction with, and Oppoſition to the Sun, as now: As alſo this Plane lying through the Sun and Earth, ſhe could never have been before, or behind the Earth in its annual Courſe, but ſtill equally advanced with it. Thus far you conceive?

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M. Eaſily; for this Plane ſtanding erect above the other, like the Leaf of a Book, muſt have moved round as the Earth moved, ſo as to paſs always through the Centers of the Sun and Earth: But ſtill we ſhould have had our full and new Moon regularly as at preſent.

P. Hold a little. —— Then you will allow, ſince this Plane ſtood erect above the other, like the Leaf of a Book, that the Way of the Sun and Moon muſt have lain perpendicularly to, or acroſs, each other?

M. Right; for then the Moon muſt have come over our Heads from North to South, or from South to North at leaſt.

P. She muſt certainly have paſſed thro' the Poles of the Ecliptick; and conſequently, through or near the Poles of the World.

M. Let me conſider this Circumſtance, —— I ſee the Plane of her Orbit muſt always have paſſed through the Poles of the Ecliptick; ——And ſince our elevated Pole always points to the North, her Plane muſt have paſſed through the Poles of the Equator too, when the Earth was in the Solſtices; for paſſing ſtill through the Center

of the Sun, it muſt then have lain directly South and North. And at all other Times it muſt have paſſed a little beſides the Poles of the World.

P. Then the diurnal Rotation of the Earth could not have cauſed the Moon to riſe and ſet to us every Day, as ſhe does now; for when ſhe was about the South Pole, we could not have ſeen her for many Days, more than now we ſee the Southern Conſtellations, which never appear above our Horizon. And beſides, ſhe muſt have lingred long about the gloomy Horizon, either in coming in, or going out of Sight, having but twelve Degrees of meridian Altitude the firſt Day of returning from the South, and twenty-four the next.

M. I was not aware of this. It is ſtrange enough. All the Time likewiſe ſhe ſhould be about the northern Parts of the Globe, ſhe muſt be hid to thoſe lying on the other Side the Equator; and the moſt conſtant Part of her Light muſt have been ſhed over the frozen Regions of the Earth, where there are few Creatures, at leaſt rational Inhabitants, to perceive the Benefit of it. This muſt have been a palpable Miſcalculation, to make the Light of the

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Moon take a different Courſe from the Light of the Sun, and ſo leave the populous and habitable Parts of the Globe worſt provided for.

P. There is ſtill another Inconvenience, not leſs than this: For ſince the Moon muſt always have moved upon (or near) a vertical Circle, paſſing through the Center of the Sun, ſhe muſt for half of her menſtrual Courſe have come to our Meridian almoſt at the ſame Time with the Sun, or about twelve o'Clock of the Day: That is, our Moon-Light muſt have happened, for the half of her Revolution, by Day; when it could not have been perceived, nor done us any Service.

M. It muſt indeed have been ſo, ſince the Half of that Circle muſt have come above, or fallen below our Horizon, nearly with the Sun; which would have been a diſadvantageous Change to us in Point of Light and Variety.

P. Things would have been different from what they are in moſt other Reſpects: Our periodical and ſynodical Months would have been the ſame; and the Tides muſt have ſwelled for ſome Days together about either Pole, once a Month, without a Tide

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on the oppoſite Part of the Globe, as now; and there muſt have been an Eclipſe of the Sun every Conjunction, and of the Moon every Oppoſition.

M. I underſtand; it muſt have been ſo, becauſe the Plane of the Moon's Orbit paſſed through the Centers of the Sun and Earth. ——And theſe ſeveral Circumſtances may, I think, ſuggeſt to us the Inconveniencies we ſhould have ſuffered, if not the Moon, but the Earth itſelf, had thus moved from North to South, inſtead of moving from Weſt to Eaſt, which certainly was not impoſſible.

P. That the Equators of the diurnal Motions of all the Planets were nearly obverted to the Sun, was Matter of Choice, and not of Neceſſity. Had the Way of the Sun lain through the Poles of the Earth, as you ſuppoſe, the Conſequences muſt ſtill have been more inconvenient.

M. We never conſider theſe Caſes as poſſible; and hence it is that we never contemplate the Wiſdom and Kindneſs of the Deity in the preſent Conſtitution.

P. I am perfectly charmed, *Matho*, with your pertinent and rational Reflections: The greateſt Philoſophers loſe the beſt Part of

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their Pleaſure ariſing from the Study of Nature, for Want of ſuch Obſervations.—

M. The Conſequences of this Suppoſition I ſhall endeavour to find out by myſelf, ſince you have put me in the Way: But you ſaid the Plane of the Moon's Orbit might have lain acroſs the Plane of the Earth's Orbit many different Ways.

P. It might not have lain through the Sun, but parallel to his Diſk, or at right Angles to itſelf in the former Poſition: And then it muſt alſo have gone through the Poles of the Ecliptick, and thoſe of the Equator likewiſe in the Equinoxes.

M. It muſt, as lying then directly North and South; or being every where at right Angles to itſelf, as in the former Suppoſition.

P. In this Caſe the Moon would ſometimes have been before the Earth in its annual Courſe, and ſometimes behind it, as at preſent; but could never have come into Conjunction with, or Oppoſition to the Sun, but have always kept at an equal Diſtance from him.

M. This Suppoſition is, I think, ſtill worſe than the laſt, ſince the Moon then muſt not only have ſpent a good Part of her men-

menſtrual Revolution about the Poles of the Globe, but could never have ſhone upon us with her full Luſtre, as never coming to an Oppoſition with the Luminary from which ſhe borrows her ſplendor. Ninth Conference.

P. And worſe likewiſe, in that being now attracted by the Sun and Earth in two different Planes, her Motion muſt have become quite perplexed and irregular.

M. Pray help me to underſtand this?

P. You know the Plane in which ſhe is now ſuppoſed to move, ſtanding erect, like the leaf of a Book, to the Plane of the Earth's Orbit, and not paſſing through the Sun; his whole Force muſt then have been exerciſed to bring down that Plane nearer to the Earth's; and that on whatever Side of the common Section of the two Planes ſhe was.

M. I conceive it; in the laſt Suppoſition, where the Plane of her Orbit paſſed through the Sun, he muſt have accelerated her in her Courſe, but could not have drawn her out of the Plane in which ſhe moved; whereas here the Lines by which ſhe is attracted to the Sun and Earth, could never be in the ſame Plane, except when ſhe was in the Interſection of both Planes: Which

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muſt make her dip, or move in no certain Plane. And as ſhe would be drawn forward or nearer the Sun, the farther ſhe moved from the common Section on either Side, we ſhould ſtill loſe more of her Light.

P. You hit the Caſe perfectly: She could never be attracted by Lines in the ſame Plane, except when in her *Nodes* (as they are called;) and a ſmall Digreſſion of this Sort at preſent cauſes a conſiderable Irregularity in the Moon's Motion. —— And, as I ſaid, there are innumerable other Poſitions between *theſe two*, in any of which the Plane of the Moon's Orbit would have been erect to that of the Ecliptick: But as they had been near the one or the other of the two Poſitions we have ſpoke of, ſo they muſt have participated of the Diſadvantages proper to either the firſt or the laſt.

CXX. *M.* You have now, *Philon*, been better than your Word. I not only myſelf underſtand the Beauty and Uſefulneſs of the preſent Diſpoſition, but could even ſhew to another the Inconveniency and Loſs we ſhould have ſuſtained, had the

the Plane of the Moon's Orbit croſſed that of the Ecliptick. And the ſame Reaſoning ſeems to be applicable to the Moons of other Planets, which muſt have been leſs carefully provided for, had the Planes of their Satellites lain acroſs the common Plane.

P. There is all the Parity of Reaſon between their Caſe and ours, that can be between two Things of the ſame Kind.

M. From this notable Contrivance then, as well as from all the ſolicitous Proviſion we obſerved to be made before, it ſeems to follow, that the Uſe of the ſecondary Planets is only to reflect the borrowed Light of the Sun upon their Primaries.

P. That would be too raſh a Suppoſition.

M. Pray wherein does the Raſhneſs of it conſiſt?

P. Our Earth performs the ſame Service to the Moon as the Moon does to it; or rather a great Deal more, ſince it reflects upon her about fifteen Times a greater Light than it receives from her: Yet no Body would ſay, that it was the only, or the principal Uſe of the Earth to reverberate the

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the Sun's Light, in Order to illuminate the Moon.

M. That Aſſertion would be both falſe in Fact, and abſurd in Reaſon. The Earth's being a habitable Globe is certainly the principal Deſign of it: And if it illuminates the Moon, it does that only as an acceſſory End, without Prejudice to the principal Uſe. But pray is our Earth *a Moon* to its own Moon?

P. Not to ſtand on the Novelty of the Expreſſion, it is in Effect a Moon to its own Satellite: For ſince both Bodies are dark, or untranſparent, there is the ſame Neceſſity for their reflecting the Light of the Sun on each other mutually; but the Earth reflects it much more copiouſly on the Moon, as being by far the greater Body. Which is manifeſt from bare Inſpection; for a little after the Conjunction, the Part of the Moon, not yet enlightned by the Sun's Rays, becomes conſpicuous to us by the Light reflected on her from the Earth.

M. I have in Truth obſerved it very diſtinctly; and from her Appearance at that Time there ſeems to be a good Degree of

of Light reflected on her: For I have perceived it even before our Day-Light was quite gone.

P. You may conſider what Effect the Moon-Light would have, if it became 15 or 16 Times brighter; for ſuch is the Moon-Light of the Moon, if I may ſo expreſs it: And if you can read a ſmall Print by our Moon-Light, what might you do there?

M. Fifteen Times our Moon-Light would make a Kind of Day-Light, I fancy; and we might travel, and do all Manner of Buſineſs by it, as conveniently at leaſt as now in gloomy Weather.

P. The Earth, *Matho*, muſt appear there by Night a Globe near ſixteen Times larger than the Body of the Sun himſelf; and therefore muſt throw a vaſt Gleam upon a Spectator in thoſe Parts.

M. You mean, *by Night* at the Moon, and not by Night with us.

P. Your Correction is juſt; that is my Meaning.

M. This muſt be a fine Sight ſurely, to ſee a Moon ſo large! But pray, as we perceive their Moon-Light, or the Light reflected from our Globe on them; could they

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they perceive our Moon-Light, or the Light reflected by the Moon on our Earth?

P. I do not think they could; for if their Moon-Light were but a fifteenth Part of what it is, we could hardly perceive it at this Diſtance.

M. I deſigned to have aſked you almoſt every Time I came here, after our firſt Meeting, how it comes to paſs that the Moon appears in ſuch various Forms: But from what has been ſaid juſt now, and at different Times before, I think I almoſt underſtand the whole Affair, without giving you farther Trouble.

P. It ſometimes ſo happens that, by reflecting on a Subject we come to have right Notions of it, without a formal Enquiry: But pray, what are your Thoughts of the various Appearances of the Moon?

M. Being an opaque Body, and therefore neceſſarily reflecting the Sun's Rays, ſhe muſt appear of different Forms to us, as the Hemiſphere enlightened by the Sun, is more or leſs turned to us. Therefore in the Conjunction ſhe is quite inconſpicuous, except perhaps by appearing on the Face of the Sun in an Eclipſe, as a dark Circle: In the Oppoſition ſhe muſt appear full, for her

her Side, to which it is then Day, is expoſed to us; and between *theſe two* ſhe muſt put on all the intermediate Appearances. I likewiſe eaſily conceive from this, why before and after the *Change*, her Horns are turned contrary Ways, ſtill from the Sun, to wit; and her luminous Edge towards him; for her enlightened Half is then going out of, or coming into our View. Ninth Conference.

P. You are perfectly right. I had prepared for you this Figure of her different *Phaſes*, which can be of little other Uſe to you now, than to ſhew you that the Earth puts on all the ſame Variety of Appearances to her, as ſhe does to it, but in a contrary Order.

M. Pray let me conſider it in that View. — I underſtand it eaſily: When we have the new Moon, the Earth muſt appear at the full to her; for her dark Side being then towards us, it is Night there. As her Light increaſes to us, ours muſt decreaſe to her, by being carried more towards the dark Side of the Earth, and ſo turning her own illuminated Half to us; till ſhe comes to the Oppoſition, and ſhines full on us, when the Earth muſt be quite darkened to her, unleſs

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unleſs perhaps in the Conjunction it comes over the Sun, and wholly covers him. — O right! I ſee now that the Earth muſt appear a much larger Body at the Moon, than the Sun himſelf, when it not only covers him wholly, but hides a great Space of the Heaven round about him. I ſee now more clearly what you ſhewed me before, That ſhe takes a long Time to wade through the Shadow of the Earth, which is, even there, near four Times broader than herſelf. Well, I am delighted with all this, it is ſo plain, and at the ſame Time ſo agreeable too.

CXXI. *P.* A Spectator at the Moon muſt alſo enjoy a pleaſing Spectacle, *Matho*, in beholding the Converſion of our Earth on its Axis in four and twenty Hours.

M. How would that appear to him?

P. By Means of this Rotation, he would be furniſhed with a conſtant Variety of Objects on his Moon, offering themſelves to him ſucceſſively. Our *Seas* and *Continents* would there be ſeen from a right Point of View, and be remarkably diſtinguiſhed by a different Brightneſs of Colour. The Water, you know, drinking up the Rays,

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Rays, reflects but few of them comparatively; the Parts of our Globe therefore covered with that Element, muſt appear darker: But the ſcorched Plains of *Africa*, and thoſe Countries that lie under the Equator, muſt have a ſtrong Splendor.

M. This muſt certainly be very entertaining. *Madagaſcar*, *Borneo*, *Sumatra*, and the other Iſlands of that Tract, muſt make bright Spots amidſt the Ocean; while the *Mediterranean*, the *Euxine*, and *Caſpian* Seas, by their Darkneſs, ſet off the Luſtre of the neighbouring Continents. I cannot help thinking that a View of our own Globe from ſuch a Diſtance muſt be very agreeable. Twelve Hours muſt change the Scene to a Spectator at the Moon, from *Tartary* and *Aſia* to the two Continents of *America*. He could not help being ſurprized, I fancy, with the narrow ſhining *Iſthmus* that joins them together. He would likewiſe ſee, I ſuppoſe, Tracts of Land, which we ourſelves have not yet diſcovered, or know only a little of their Coaſts.

P. He would certainly ſee ſome Parts of our Globe which we never ſaw, nor perhaps ever ſhall ſee. For while the Earth, in its annual Courſe, turned its North and South

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South Poles alternately to the Sun, he muſt perceive the *vaſt circumpolar Regions* quite unknown to us.

M. From all theſe Particulars I am ſatisfied, that the Earth muſt make an entertaining and noble Appearance at the Moon.——

P. But if you go on to conſider thoſe larger Bodies, *Saturn* and *Jupiter*, they make ſtill an incomparably more glorious Figure to their Satellites; each of them appearing ſome hundred Times larger than the Sun does to us, and many thouſand Times larger than the Sun appears to themſelves.

M. Let me intreat you to ſhew me how this is.

P. As the Matter is become quite eaſy to you now, there is no Occaſion for Intreaty. *Jupiter*'s Diſk is in Reality a hundred Times larger than that of the Earth; and the innermoſt of his Moons is not quite ſo far diſtant from him as our Moon is from us: Therefore he muſt appear to the innermoſt of his Moons a hundred Times larger than the Earth does to our Moon. But the Earth appears to our Moon near 16 Times larger than the Sun does to us;

ſo

ſo that *Jupiter* appears to the innermoſt of his Satellites almoſt 1600 Times larger than the Sun does to us. Ninth Conference.

M. This would be an inconceivably new and glorious Sight in our Parts of the Syſtem!

P. Add to this, ſince the Sun's Diſk appears 25 Times leſs there than to us; *Jupiter* appears 40000 Times larger to the neareſt of his Satellites than the Sun himſelf.

M. If I did not all along perceive the Reaſons on which your Numbers are founded, I ſhould think you only deſigned to indulge me in a little vain Amuſement; but as it is, I am really convinced of the Truth of what you advance.

P. Theſe Numbers and Proportions are not much over nor under the Truth; but where there was nothing that required any great Exactneſs it would have been needleſs to have affected it.

M. Pray ſhew me next what Appearance *Saturn* makes to his Moons?

P. *Saturn*'s Diſk is 64 or 65 Times larger than the Earth's: Therefore he appears to two or three of his neareſt Satellites 64 Times larger than the Earth does

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to our Moon; and of Conſequence, upwards of a 1000 Times bigger than the Sun appears with us. The Sun's Diſk there is near a 100 Times leſs than here. *Saturn* therefore at the Diſtance of our Moon appears about 100000 Times bigger than the Sun himſelf does. Thus *Jupiter* and *Saturn* muſt appear to their Satellites, not as Moons but prodigious reſplendent Orbs in the Heaven, taking up no ſmall Space in the azure Firmament with their luminous Bodies. For on allowing *Jupiter*'s Diſk to appear 1600 Times larger than the Sun's to a Spectator on our Earth, you will find that his Diameter extends to more than one and twenty Degrees in the Heavens.

M. I want to ſee this more particularly?

P. The Sun's mean Diameter with us is about 32 Minutes, or half a Degree and two Minutes: But the Square Root of 1600 is 40; 40 Times the Sun's Diameter therefore is about 21 Degrees 20 Minutes.

M. This is plain: But pray repreſent the Thing to my Imagination, if you can.

P. Twenty Degrees is about the ninth Part of a Semi-circle: So that nine ſuch Bodies

Bodies as *Jupiter* appears to his neareſt Satellite muſt do more than reach from one Side of the Heaven to the other. Ninth Conference

M. This gives me Satisfaction; and I find we have no Notion of ſuch Luminaries in our Part of the Syſtem; for when *Jupiter* riſes to his Satellites, a whole Quarter of the Firmament muſt ſeem in a Blaze of Light.

P. He appears leſs to the Reſt of his Satellites; but ſtill larger than any Luminary we have a Notion of.

M. And *Saturn*, what Figure does he make to his Satellites?

P. To the innermoſt of his Satellites he appears of incredible Bulk; bigger than *Jupiter* himſelf to the innermoſt of his; if it were worth the while to be particular on theſe Things: But at the Diſtance of our Moon his Diſk is about 1024 Times larger than the Sun's to us. The Square Root of this Number is 32 nearly; his Diameter therefore at this Diſtance is about 17 Degrees; or ten and a half ſuch Bodies as he, placed by each other's Sides, would extend over the whole Heaven, from Eaſt to Weſt.

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CXXII. *M.* All this is ſo new and ſurpriſing to me, *Philon*, that I cannot ſufficiently expreſs my Admiration of it. You convinced me before that the *Heaven* of *Jupiter*, or *Saturn*, was beautiful and glorious: But this View of the *Heaven* of their Satellites ſurpaſſes the Force of Imagination. For we may add to this, I preſume, that every Satellite enjoys a fine Proſpect of its neighbouring Moons, which muſt appear to it, as well as to their primary Planet.

P. It muſt be ſo, ſince they are reaſonably ſuppoſed not to be leſs than our Earth: If ſo, when one of them is in the Oppoſition, or near it, and the *next inferior* aſcending towards it; the higher muſt appear to the lower, larger than our Earth does at the Moon. But it would be endleſs to purſue the ſeveral Appearances they make to each other.

M. Pray what can be the Uſe of this Profuſion of Light, thrown on theſe ſecondary Planets, even by their Primaries themſelves? Or of that Light reflected on our Moon by the Earth?

P. What ſhould the Uſe of it be, but that they may have Light enough to ſee to keep

keep to their Orbits regularly? Otherwiſe, revolving in thoſe vaſt, pathleſs Spaces above, they might have miſſed their Way. Ninth Conference.

M. Ah, *Philon!* can you find in your Heart to joke at this Rate, on ſuch a Subject! Let me beg of you to tell me what can be the Uſe of all this Light? For it is certain, that a Thing thus laid out with ſo much Study, and executed by ſuch mighty Contrivance, cannot be without Deſign, and for no Purpoſe.

P. I wonder, *Matho*, you did not firſt aſk me, What was the Uſe of all that Light, ſhed on the primary Planets by their Secondaries? Or by the Sun himſelf? Can this be without Deſign, more than the other?

M. What ſurpriſed me moſt was, That the primary Planets ſhould be *Moons* to their own Moons: This made me aſk the Queſtion at firſt; though I find I am ſtill as ignorant of the Queſtion you put, and which I ought more naturally to have aſked in the firſt Place.

P. Can the Light then ſhed on the greater Planets be without Deſign, more than that ſhed on the *leſſer?*

M. Moſt undoubtedly it cannot. The *Almighty Architect* would never have made

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uſe of ſuch laborious Methods as we have ſeen, to furniſh the moſt remote Bodies of our Syſtem with ſuch Variety of Light, if Light had not been abſolutely neceſſary to them.

P. And what is it in the Nature of Things, that can make Light abſolutely neceſſary to thoſe great Bodies lying at ſuch a Diſtance from the Sun; and with which you ſee they are ſo wonderfully ſupplied?

M. I cannot indeed tell; but expect that you ſhould anſwer this Queſtion yourſelf.

P. And yet I ſhould think that ſuch a Queſtion were not difficult to be anſwered. Tell me, What is the Uſe of the Light of the Moon to our Earth?

M. This I can eaſily anſwer. The Moon illuminates the darkened Part of the Earth in the Sun's Abſence; ſhe directs the Traveller in his Way, and the Sea-faring Man in his Courſe by Night; and divides our Time to us in a different Manner from what the Sun does.

P. Very good: But would the *Terraqueous Globe* itſelf (I mean the *Mountains*, *Fields*, *Rivers*, *Ocean*,) ſtand in need of Light, if it were not inhabited? Or what is it in the Nature of Things, for which Light

Light is appointed; and to which it anſwers? To Eyes, or to Ears? You ſee we ſtand in need of Light in our Houſes; but could there be any Neceſſity for theſe, if the Houſes were uninhabited; if no Body dwelt in them? Ninth Conference.

M. It is enough, *Philon*; pardon my want of Thought. I ought to have been upon my Guard, when you began with your ironical Way of Joking. You mean, that all the other Planets, as well as our Earth, are habitable Globes, and the Reſidence of ſuch to whom the Light of the Sun may be ſerviceable; or, to ſpeak more juſtly, to whom it is altogether neceſſary.

CXXIII. *P.* Why was a Sun neceſſary at all in the Syſtem, *Matho*, if not upon this Account? Why might it not have been a dark, a torpid, and a motionleſs Abyſs? Or why was the Frame of Nature built at all? —— Theſe are Queſtions we ſhould know how to anſwer, if we are capable of anſwering any thing; if we know whether we were made by *Chance*, or *a deſigning Cauſe*. Every body will own that the Syſtem required a Sun, regular Motions and the preſent Contrivances; becauſe it was to be

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inhabited. —— Right: But was it to have a Sun, and theſe Conveniencies, that only the hundredth Part of it, nay that leſs than the hundredth Part of it, ſhould be inhabited? Was it to have theſe Contrivances, that it might be uninhabited even where they ſeem to have been moſt ſtudied? For, if we may compare the Works of the Creator among themſelves, the Contrivances for illuminating the ſuperior Planets are, without Controverſy, extremely more ſtudied than in the lower Parts of the Syſtem. Call to Mind again the Heavens of *Jupiter* and *Saturn*, what bright Parts of the Univerſe thoſe are; tho' ſo far removed from the Sun. Theſe Bodies, you owned, appear to each other vaſt Globes of Light, far exceeding the Notion we have of *celeſtial Luminaries*. If we ſuppoſe a Spectator brought from thence to our Regions, he muſt think he were conveyed to a dull and languiſhing Part of Nature.

M. You have ſhewn me that Particular to Satisfaction: But I ought to have foreſeen this Conſequence long ago, when I obſerved ſuch various and artful Proviſion made for throwing Light on all the Parts of the planetary World; when I beheld the Planets placed, not one without another, but five or ſix of

them ſo diſpoſed at the ſame Diſtance from the Sun, that they might all enjoy his Light equally, and reflect it likewiſe on each other mutually. This is ſuch an expreſſive Artifice, as is not eaſy to be miſtaken: Otherwiſe what Difference would there have been, whether the Planets had been placed far from, or near the Sun; were they not to have been repleniſhed with Inhabitants, who might perceive the Advantage of the Light? Or what needleſs Work had it been, ſo carefully to provide the Comforts of *Living Beings* for Things void of Life?

P. This Conſequence ſeems to be implied, *Matho*, from the very Time we underſtand the Sun to be ſuch a vaſt Body, merely upon the Account of the Planets. He was to keep them near him by his Attraction, and to cheriſh them by his Heat and Light. But to cheriſh what? Some mighty Globes of Marble, for Inſtance, ſome huge Maſſes of dead Matter! No Reaſon at all would be better than this.

M. I confeſs I ought to have conſidered the Work in this View, when firſt I underſtood that the Planets were made to revolve about the Sun by ſuch wonderful Power; that they might move without changing Diſtance

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ſtance from their Center of Heat and Light: And when I firſt ſaw that they rolled round on their Axes, that they might enjoy the Light and Shade alternately. No Eyes could bear a perpetual Splendor. But above all, I ought to have foreſeen this Deſign of the Work, when I ſaw Planets revolving about other Planets, and thoſe revolving about the Center of Heat and Light! This could not be a mere Flouriſh of Skill in the *Almighty Architect*; an ambitious affected Ornament, that ſerved only to ſhew what he could do when he had a Mind.

P. You are grown a powerful Orator for this Side of the Queſtion, all of a ſudden, *Matho.*

M. I am ſerious in what I ſay, and do not talk thus out of an Affectation to be thought to underſtand a Thing, before I ſee it. When I reflect on all we have ſaid from the Beginning, it appears to me conſiſtent in this Senſe; but without this it ſeems ſcarce to have a Meaning: Every thing indeed confirms it, and nothing, ſo far as I know, makes againſt it. For why ſhould our Earth alone of all the Planets be furniſhed with Inhabitants; ſince it is neither the greateſt, nor the innermoſt, nor the outermoſt, nor

the

the beſt furniſhed with Light, or with Variety of it, to receive them: I ſay, why ſhould it of all the Planets be graced with Inhabitants, while others, either larger, or nearer the Source of Heat and Light, are left empty and deſolate? It vaniſhes long before we come to *Jupiter* or *Saturn*, the leaſt of whoſe Satellites are probably as large. It is placed, ſuppoſe, at 21000 of its own Semi-diameters from the Sun: What is the Meaning then of *Jupiter*, a much larger Body, placed at 5 times that Diſtance? Or of *Saturn* placed at near 10 times that Diſtance? Or of *Venus* placed at 1500 ſuch Diameters from him? Could not this Earth have rolled round the Sun, and been inhabited, unleſs it had been attended with thoſe larger Bodies, rolling likewiſe round him without Inhabitants?

M. I think therefore, *Philon*, we ſhould never look to the Heavens, and thoſe mighty Bodies that roll round with us; nor conſider that their Motions are governed by the ſame common Laws, nor ſuffer our Thoughts to riſe above the Surface on which we tread; unleſs we come into this Opinion: For it appears to be *that*, which can only ſolve a thouſand Doubts in our Mind, and free us

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from a thouſand Abſurdities, which we muſt otherwiſe entertain concerning the *great Architect* of the World.

P. There ſeems in Truth to be no Medium, between remaining quite ignorant of all the Miracles of Power, and Wiſdom, which appear in the Heavens, and coming into this Notion: And on this Account it was, that Men came into it, as ſoon as they began to compare this Earth with the other great Bodies in Nature, and found that it was but as a Point in Compariſon of the Univerſe. But

CXXIV. Since you have ſo little Doubt of the primary Planets being habitable, what do you think muſt be the Uſe, or the Deſign, of that more copious Light reflected on the Moon by our Earth; or by thoſe larger Bodies *Jupiter*, and *Saturn*, on their Secondaries?

M. I ſhall not readily forget theſe laſt; and as more ample Proviſion hath been made for them, than for the primary Planets themſelves; they cannot be idle *Phænomena* in the Sky, to amuſe —— I know not what Beings, if none are there: But the different Abodes rather of ſome ſort of living Creatures:

tures: For thus the Convenience *of more* is conſulted, as I remember you obſerved ſome Time ago. Ninth Conference.

P. Certainly the Syſtem is then of more Uſe; nor can it be conſtrued a Blunder, or Miſunderſtanding of the Deſign, if the Works of the *Author of Nature* are not idle, or employed to ſmall Purpoſe.

M. It is rather true on the contrary that, the more uſeful they are, the more ſkillful they muſt be accounted. *A large Deſign, with ſmall Convenience* ſhews that the Artiſt was not Maſter of his Buſineſs.

P. You expreſs the Caſe with Propriety. It might be ſaid that our Seas are large; but we have ſeen that they are referred to the Uſes of Habitation; and beſides they are the Nurſery and Seat of numberleſs Species of living Creatures: Our Mountains are wild; but they are notwithſtanding a continued Scene of Vegetation and Life, and not uſeleſs Deformities on the Face of the Globe.

M. And by a Parity of Reaſon, theſe ſecondary Planets certainly anſwer a more noble End, if they are equally the Seats of living Beings, than if they only reflected the Light emptily, on other empty Globes.

Without

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Without this we cannot imagine to what Purpoſe ſuch vaſt Spheres ſhould bandy the Sun's Splendor from one to another, and keep up an *eternal Dance*, unperceived by any Creature, unleſs perhaps by a few ſtudious Perſons here on Earth, peeping through a Teleſcope. I cannot bear to think that ſuch wonderful Sights ſhould have been ſo far removed from us; if there were none elſe to admire them.

P. The Thought indeed ſhocks common Senſe. But it is likewiſe of Conſequence in this Affair, *Matho*, to conſider that on the Surface of the Moon (the neareſt of thoſe Bodies to us) as ſeen through the Teleſcope, frequent *Mountains*, higher than ours, *Rocks*, *Lakes*, and Seas are diſcovered; all which ſhew a Planet not unfit for Habitation, but diſpoſed like to our Earth.

M. Something like this is perceived even by the naked Eye.

P. Here is a pretty exact Figure of the Moon, *Matho*, as obſerved through the Teleſcope.

M. Pray let me look at it. There is indeed a great Inequality on her Surface here, and Variety of Light and Shade; for ſome Parts are very dark, and others reſplendent.

I don't

I don't know whether there be ſuch a Difference of Appearances even on the Surface of our Earth.

P. You cannot, unleſs you were to ſee it from the Moon.

M. What ragged and broken Places are theſe, on the Edges of theſe leſſer Figures?

P. Conſider how large theſe Objects muſt be in themſelves, when they lie at near 24000 Miles Diſtance from us! Theſe are *Rocks*, *Mountains* and *hollow Vallies*, which become thus conſpicuous in certain Poſitions of the Moon, with reſpect to the Light of the Sun: The Tops of theſe Mountains appear thus by the Rays of the Sun ſtriking on them, before the Light hath reached thoſe Parts of the Moon's Surface, where they are ſituated.

M. Surely the Uſe of theſe *Inequalities* and *deep Shades* that appear, cannot be to reflect the Light on us: Such large Heights and Declivities ſeem rather fitted for the Deſcent of Waters, and the Uſes of Vegetation.

P. What you obſerve ſeems of great Weight: No body can be ſo fanciful as to imagine that thoſe *dark Tracks*, and *deep Shades* are deſigned for the Reflexion of the

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the Sun's Rays. But it is farther obſerved, that theſe Shadows ſeen on the Surface of the Moon are contracted, as thoſe Parts of her Diſk are more turned to the Sun: Juſt as the Shadows of our Mountains become ſhorter, as the Sun riſes higher; and quite diſappear in the Height of the Day: Which ſhews that it is but a ſecondary Uſe of this Planet to reflect the Sun's Light back on the Earth. If that had been the only, or the principal Uſe of the Moon, ſhe muſt have had a certain equable Roughneſs of Surface, like an unpoliſhed Block of white Marble, for diſperſing the Sun's Rays every way: But no Riſings, or Inequalities, like Rocks or Mountains. But the Author of Nature, who is the *firſt Optician*, and knew what Effect her preſent Surface would have at the Earth, hath given her a Mixture of the one and the other, to anſwer different Ends. And hence it is that we receive great Aſſiſtance even from her reflected Light: And ſhe receives greater from our Earth, though made unequal by Mountains and Vallies. In ſhort, the moſt diligent Obſervers of this Planet conclude, that our Earth ſeen there would make juſt ſuch an Appearance to the Eye, (though

(though much larger) as the Moon does to us here. Ninth Conference.

M. This Point ſeems to be out of Doubt, unleſs we would inſiſt on Proofs which cannot be had, from the Nature of the Caſe: For, ſince our Earth is an habitable Globe, and at the ſame Time ſerves as a Moon, there is certainly equal Reaſon for concluding, that the Globe, which ſerves us for a Moon, ſhould be habitable too.—I remember you ſaid before, that the *Arch*, which ſurrounds the Body of *Saturn*, ſeemed not wholly deſigned for reflecting the Light on the interior Planet; ſince it keeps off as much at one Seaſon, as it reflects at another: Now pray what may your Thoughts be of this ſingular Piece of divine Workmanſhip?

P. It is more eaſy (as I ſaid then) to tell you what I do not think of it, than to form any conſiſtent Thought about it. I do not think it the Ruins of an exterior Cruſt, the reſt of which hath fallen down upon the Body of *Saturn*. The Dilapidation of a Planet hath to me a ſtrange Sound; nor are Ruins wont to be ſo regular: Though even that would make it originally deſigned for Habitation. Nor can I think it is a fluid Body. It muſt then indeed have a ſwift Ro-

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tation on its Axis, to give every Part of it a centrifugal Force equal to its Gravity, and hinder it from falling down, the Time of which might eaſily be aſſigned: But I do not ſee why it ſhould then be flat and broad, with the Edge towards us; it ought rather, I think, to be of a round or cylindrical Form. So that it appears more probably to be ſolid.

M. You ſeem inclined, I think, to ſuppoſe that this *pendulous Structure* may even be habitable.

P. Every Body in Nature, *Matho*, is pendulous, tho' in different Circumſtances from it. There is no Abſurdity in ſuppoſing it may be habitable, and ſerve at the ſame Time for ſome great Purpoſe to the Planet it ſurrounds, as well as receive Advantage from it: But the ſafer Way is to own, that it demands our Admiration, while it is beyond our Reach to diſcover the Uſe for which it was thus contrived.

M. Leaving this Body therefore as we found it; this I think ſeems to me beyond rational Doubt, that all the Planets, primary as well as ſecondary, are the Abodes of ſome ſort of Inhabitants or other.

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CXXV. *P.* Conſider then in the next Place, *Matho*, whether a ſkilful Artiſt could deſign that which is of greater Dignity, only for the ſake of the inferior Part of his Work?

M. Here, *Philon*, I fancy I gueſs what you intend by this Queſtion; and the Anſwer is obvious: A ſkilful Artiſt could neither deſign ſuch a Blunder; nor could a fair Enquirer in the preſent Caſe imagine, that *Man* was made for the ſake of the Brutes, nor the inferior Animals for the ſake of the Vegetables, nor the yearly Production of Vegetables for the Relief and Comfort of the Soil on which they grow. This would be to turn the Bottom upward, and invert the Order of Things. I have not forgot what you ſhewed me concerning the *riſing Scale* of created Beings. This *Gradation* is the Voice of Nature, as well as of Reaſon, and confirmed by conſtant Obſervation of the different Species of Things on and about our Earth. The Relation and Aptitude of one Thing to another, where the *Unity of Deſign* appears through an infinite Variety of Particulars, always riſes upward.

P. You reſume the Subſtance of what we then ſaid, in a juſt and expreſſive Man-

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ner. —— For whoſe ſake then, tell me, was this Earth formed, furniſhed out, and placed to revolve among the reſt of the Planets; for the ſake of the rational, irrational, or vegetating Beings on it?

M. This Queſtion is ſo plain, that I know you will hardly expect I ſhould give you a direct Anſwer: But you mean that the other Planets, as well ſecondary as primary (which appears now to be rather a nominal Diſtinction, than to imply any real Difference of their Uſe and Nature) could not have been made on the Account of brute Animals, which can neither conceive the Beauty of the Work, nor acknowledge the Benevolence of the Creator, nor have their Nature improved by the Power and Wiſdom diſplayed in the Order and Variety of the Parts.

P. Undoubtedly, *Matho*, the ſame Reaſon holds, and is indeed ſtronger with reſpect to the reſt of the Planets, than to our Earth. For if it would have been unſuitable to have peopled a leſſer Planet only with brute Beaſts, it had been ſtill more abſurd to have made the Syſtems of *Saturn* and *Jupiter*, only for the ſake of irrational Animals. Wherefore a *nobler Gueſt* was to be placed in thoſe magnificent Globes; who, though perhaps not reſembling

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reſembling us in all Particulars, may nevertheleſs be endued with the ſame rational Nature, and that poſſibly in greater Perfection, in Proportion to the Dignity of thoſe nobler Manſions. —— It is ſtrangely inconſiſtent with Reaſon, to imagine this vaſt Structure of the Univerſe to have been raiſed up in immenſe Space only to be the Seat of eternal Silence and Solitude; the ſtarry Worlds on high unfolded, the harmonious Motions of the Planets contrived, and all adorned with amazing Splendor and Brightneſs, only that wild Beaſts might have a more convenient Retreat!

M. Ah, *Philon!* name not ſuch a grievous Abſurdity! It ſhocks Nature, and affronts the *Infinite Reaſon?*

P. Wherefore, I ſay, a *more divine Nature* than ſuch Kind of Beings, was wanting to complete the Deſign; a Nature ſanctified with Reaſon, aſpiring after the endleſs Improvement of the rational Faculties, ſearching into the neceſſary and eternal Reaſons of Things, itſelf deſirous of, and deſigned for Eternity. For Reaſon moſt plainly denies that a rational Nature ſhould ever die.

M. You carry me irreſiſtibly along with the Strength and Pleaſure of the Argument.

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It muſt be allowed that God, who is the *Infinite Reaſon*, cannot but delight in rational Works; nor can he be the Creator of other Things, except ſo far as they are ſubſervient to theſe. It is thus the Government of Reaſon is known from the Temerity of Chance.

P. Your Inference is ſolid, and of the laſt Importance: And from thence it will follow, that he could only have been the Creator of inert Matter, or of a ſenſitive and irrational Nature, ſo far as they regard ſomething higher. And wherever that, which was made for the ſake of another, is, there that, for whoſe ſake it was made, muſt be.

M. How vain and peeviſh is *Man*, who makes himſelf the only Favourite of Heaven, and claims to himſelf alone the Care of Omnipotence! as if the Kindneſs ſhewn him ſuppoſed a Neglect of all other Things; or, as if he were injured, unleſs the Univerſe were an *infinite Waſte* to pleaſe him. How much better were it, as Modeſty requires, to acknowledge the other Bodies in the Univerſe equally dignified by *Reaſon*, with this Seat of ours!

P. I believe, *Matho*, you have ſaid more than you are aware of; the Univerſe muſt

be a *Waſte* almoſt infinite indeed, if the Opinion of the greateſt Philoſophers, founded on the Nature of Things, may be depended on in this Caſe.

M. Pray what is their Opinion? I ſhould be glad, if what ſeems ſo agreeable to Reaſon has alſo the Authority of better Judges. And it muſt, I think, appear reaſonable to every body, that the living and rational Creation ſhould be as extenſive, as the dead and inanimate Part of it; ſince it is undeniable, that the latter was made for the former. But to imagine that, while the material Univerſe is almoſt boundleſs, the rational Creation is ſo confined and narrow a Thing, that a Ship might ſail round it in a few Months, is, I'm afraid, to meaſure the Works of Omnipotence by our narrow Prejudices. —— But pray go on to acquaint me with the Opinion of the *Learned* on this Head.

CXXVI. *P.* You obſerved long ſince, if the Sun were removed always farther and farther from a Spectator, or the Spectator from him, that he muſt ſtill ſeem leſs and leſs, till at length he ſhould appear but of the Bigneſs of a larger Star, or even of a leſſer.

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M. —— And that at laſt he would quite diſappear; becauſe from the Increaſe of the Diſtance the greateſt Bodies muſt at length eſcape the Sight. Nor, I preſume, can any other Reaſon be aſſigned, except the Vaſtneſs of the Diſtance, why many Stars, which cannot be diſcerned with the naked Eye, become perceptible through the Teleſcope. And even thoſe probably are not the moſt diſtant; for the Teleſcope, as well as the Eye, muſt have its Limits.

P. Surely it muſt. Could that Invention be brought to the laſt Degree of Perfection, it would, no Doubt, diſcover to us Stars hitherto imperceptible; ſince the more perfect any Inſtrument of this Sort is, the more of thoſe celeſtial Bodies it brings within our View. It is ſurpriſing what Numbers of them have been diſcerned by this Means, in a Space where we ſee but very few, or none at all. In the *Pleiades* alone, where we can diſcover but ſix or ſeven, near two hundred have been reckoned.

M. From all this then it naturally follows, that the Diſtance may be ſo great that the Sun himſelf could not be conſpicuous from thence.

P. Or

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P. Or any Body equal to the Sun in Magnitude and Splendor.

M. That is but the ſame Caſe.

P. Now the Diſtance of the fixed Stars from us is ſo vaſt, that the Diſtance of the Earth from the Sun is but as a Point in Compariſon of it.

M. This you mentioned in our third Conference, and I have thought of it frequently ſince; for it raiſed my Admiration and Curioſity: Pleaſe therefore now to ſhew me what Ground there is for that Aſſertion.

P. You muſt firſt call to Mind that the Diameter of the *Magnus Orbis* (as it is called) or the Earth's annual Orbit, is upwards of forty thouſand Times the Semidiameter of the Earth itſelf, according to the common Suppoſition of the Sun's Diſtance; that is, upwards of an hundred and ſixty millions of Miles.

M. Could you not give me ſome ſenſible Repreſentation of this Diſtance, as you did of the Sun's Magnitude? For bare Numbers do not ſtrike the Imagination.

P. I cannot indeed: All our Meaſures, and ſenſible Images are ſwallowed up here, without being known: You ſee it is more

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than forty thouſand Times the Semi-diameter of the Earth itſelf, which is our greateſt Meaſure. Even the Moon's Orbit, which helped you to conceive the Magnitude of the Sun, could not much aſſiſt your Imagination in this Caſe.

M. Well, go on.

P. Now when the Earth is in the oppoſite Parts of its annual Courſe, or hath really advanced a hundred and ſixty millions of Miles nearer ſome of the fixed Stars, and hath left others of them ſo much behind, it ſeems not to have changed its Place with Reſpect to them, nor they to have altered their Situation with Reſpect to each other in the leaſt: Which could not be if this Diameter of the *Magnus Orbis* bore any aſſignable Proportion to its Diſtance from the fixed Stars.

M. Let me conſider this a little. —— If I ſhould travel a hundred and ſixty thouſand Miles ſtraight forward every Year, for a thouſand Years together, and yet never perceive myſelf draw nearer certain immoveable Bodies that were before my Face, nor farther from others that I ſee left behind my Back; and if one particular Body, in all that long Journey, ſhould ſtill appear with

with the ſame Degree of Elevation above my Head; —— I ſee plainly the Conſequence: Thoſe Bodies muſt indeed be at an inconceivable Diſtance from me; and the Space I had travelled over muſt bear no Proportion to their Diſtance; otherwiſe they would ſeem to have changed their Situation among themſelves; as the Objects in a large plain are thrown into a different Order, while I travel through it.

P. You have formed to yourſelf an Idea of this to better Purpoſe than I could have done: Only this is no Fiction; you are really carried thus far, not indeed once in a thouſand Years, but twice in one Year. For in Effect you are about the 10th of *June* a 1000 Times a 160000 Miles farther from the Northern Parts of the Heaven than you were the *December* before: And yet you perceive your Situation with Reſpect to them no Ways changed.

M. This then helps me to underſtand that *immenſe Triangle* you ſuppoſed drawn, of which this Diameter of the *Magnus Orbis* was the Baſe; and the two Sides meeting in the Pole of the Heavens, were yet with Reſpect to our Perception parallel. Whence we inferred that the Baſe was but as

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as a Point in Compariſon of the Sides. The one Argument illuſtrates the other: And from hence I perceive we rightly inferred the Paralleliſm of the Axis of the Earth to itſelf, in all its annual Courſe; to which chiefly we owe our Diverſity of Seaſons.

CXXVII. *P.* From this Account then how large Bodies, do you think, muſt the fixed Stars be, which are thus conſpicuous at ſuch a prodigious Diſtance?

M. Vaſt Globes certainly; not leſs perhaps than the Sun himſelf.

P. There is neither *perhaps* nor *peradventure* in the Caſe, *Matho*, for it can be ſhewn by irrefragable Arguments, that were the Sun at ſuch an immenſe Diſtance, he would not appear larger than one of thoſe Stars: Nay, were he not a luminous Globe, he could not be ſeen there at all. But thoſe Bodies are conſpicuous at greater Diſtances, than are menſurable by the Laws of Opticks. And hence it is that the moſt judicious Aſtronomers have rightly concluded, that the *fixed Stars* are prodigious luminous Bodies, equal to the Sun in Bigneſs;

neſs; or that they are themſelves indeed ſo many Suns *. Ninth Conference.

M. I ſaid *perhaps*, not that I doubted; for this Concluſion ſeems to follow from what was ſaid juſt now, *viz.* That the whole Diameter of the *Magnus Orbis* is but as a Point in reſpect of their Diſtance. But why did you ſay, That they are ſeen farther than the Laws of Opticks reach to?

P. When they are ſeen through a Teleſcope which magnifies above a hundred Times, they do not appear bigger than at preſent; or rather they appear leſs, but better defined; the tremulous Scintillation, or Sparkling, being thus cut off. Whence it is inferred that, were the Diſtance between them and us but one 99th Part of what

* Hinc patet Syſtema Planetarum circumſolarium, è fixa ſpectatum, viſum prorſus fugere, & in idem punctum lucidum confundi cum Sole, cujus Diameter inſenſibilis fiet, ſi diſtinctè ſpectetur & orbatus Capillitio, quali fixæ Terricolis cinctæ videntur. —— Ideoque viciſſim Planetæ circa *Soles iſtos* [*fixas*, ſcil.] rotati Obſervationem noſtram effugiunt penitùs. Dubium non eſt quin, oculo in fixa aliqua (aut Planeta circa illam revoluto) poſito, reliquarum circumcirca fixarum Ordo & Conſtellationum Figuræ diverſa ſint prorſus ab illis, quæ nos ſpectamus; quippe cui Sol noſter Stella fixa videtur. *Gregor. Aſtronom.* Lib. 6. Prop. 7. Coroll.

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it is, we ſhould perceive them little bigger than we do at preſent. And ſince the Breadth or Diameter of Objects decreaſes, as their Diſtance from the Eye increaſes; the fixed Stars (according to the Rules of Opticks) muſt be quite extinguiſhed, long before the Diſtance were increaſed to 99 Times as much. Whence, were the Sun at the Diſtance of the fixed Stars, he would appear only as a luminous Point, without Breadth; and were he not luminous, he could not appear at ſuch a Diſtance at all.

M. I had no Difficulty on this Head before; but what you have now added gives me ſtill more Satisfaction. And ſince in the Immenſity of Space the greateſt luminous Bodies muſt at laſt diſappear, their different apparent Magnitudes may be owing to their different Diſtances; allowing they were all equal among themſelves.

P. On that Suppoſition another Reaſon cannot be aſſigned.

M. This Boundleſſneſs of the material Univerſe diſtreſſes the Imagination; and is literally inconceivable!——

P. If then the fixed Stars are Suns equal to ours, which can only be denied by ſhutting our Eyes to theſe Reaſons; Pray for

for what Purpoſe ſhall we ſay they were created? That they might twinkle to us in a Winter-Evening through the infinite Space? Ninth Conference.

M. I foreſee what you aim at; but go on: Their twinkling to us, whatever Pleaſure it may give us, cannot be the principal Deſign of the Creator in forming them.

P. If they were ſolely deſigned for our Uſe, why are they ſo far removed from us as that we ſhould not have the full Uſe of them? —— Why are they *ſo many*, when fewer; or ſuch *great Bodies*, when leſſer Lights placed nearer to us, might have been more uſeful?

M. Do not mention ſuch an Abſurdity; no Body will ſo much as pretend it. What Uſe could this little Globe have had for ſuch a Number of Suns? Or how could it have borne them nearer? Shades and Darkneſs are as neceſſary to our State as Light itſelf. ——

P. If then thoſe Bodies are luminous Globes, equal to the Sun in Splendor and Magnitude, can they ſerve for a leſs noble Purpoſe, or be of leſs Uſe in the Creation, than the Sun himſelf?

M. Equal

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M. Equal Bodies muſt ſerve for equal Purpoſes; unleſs we would ſuppoſe that the *Author of Nature* wrought accurately only in our Syſtem, and looſely in all Parts of the Univerſe beſides. Which I'm afraid is the general Prejudice, in this as well as in other Caſes. ——

P. Do you think that to an Eye placed at the Diſtance of *Sirius*, or *Arcturus*, where our Sun would appear but as a luminous Point, the ſolar Planets could be diſcerned?

M. No; They muſt be confounded with that Point, as much (and more) as the inferior Planets, *Mercury* and *Venus*, are confounded with the ſolar Rays, at the Diſtance but of *Jupiter* or *Saturn*. —— From all this you infer (nor do I ſee what can be ſaid againſt it) That the *fixed Stars* have each their Syſtem of Planets, which cannot be diſcerned by us at this immenſe Diſtance; and that they ſhine to the Inhabitants of thoſe Regions.

P. Perhaps they ſhine to none?

M. Yes, if Light doth not anſwer to Eyes; or rather if it anſwers to nothing.

P. If then, they ſhine to any Beings, can we imagine that they ſhine for the Sake of

of thoſe who do not perceive the hundredth Part of them, without the Help of a Teleſcope, or even perhaps with the Aſſiſtance of that Invention?

M. That would be notably repugnant, to imagine they ſhine for thoſe who do not ſee them. Wherefore, I ſay, I would not have you ſo much as ſuppoſe that ſuch Uſe of them is pretended; ſince no Body, I believe, will imagine it. I readily come into your Sentiments: For, as was obſerv'd before, we muſt either not think upon this Subject at all, but forget that there are ſuch Bodies in Nature; or if we reflect upon them otherwiſe than Children do, (who look upon the Stars as ſo many bright Studs, with which the vaulted Roof of Heaven is adorned) we muſt come into this Opinion. The Inhabitants of thoſe Parts and we ſeem to be much in the ſame Condition. To a Spectator placed there our Sun muſt appear as a fixed Star, and the ſolar Planets be quite abſorbed by the Immenſity of the Diſtance: Yet it would not follow, that there was no ſuch Globe as our Earth, and that no living Being exiſted near *that fixed Star*. In ſhort, this Point can only be determined in the Nature

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of Things, by the Principles of Reaſon: And to reject it becauſe it cannot be aſcertained by Eye-Sight, or by travelling into thoſe Parts, ſeems equal to picking a Quarrel with Reaſon itſelf.

CXXVIII. *P.* If, *Matho*, any other Uſe of Light could be imagined, than to anſwer the Purpoſes of Eyes and Viſion, or if Eyes could belong to any other than a corporeal Nature, I ſhould not ſuppoſe that any Species of animal Creatures reſided in thoſe Parts: Or if it could be ſuppoſed that by far the greateſt Part of the Univerſe was to fall to the Share of brute Creatures (while a Point only was allotted for the Habitation of rational Beings, which can hardly be diſcerned among the other Bodies in the Creation;) I ſhould ſuſpect that only brute and ſenſitive Animals might inhabit the wide Expanſe of material Nature. But ſince theſe Suppoſitions are inconſiſtent with Reaſon, and inferior Creatures were only deſigned for the Sake of nobler Beings, I am forced into this Opinion whether I will or not.

M. And I, on the contrary, come into it with Pleaſure. I remember with what

Surprize

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Surprize I firſt heard of the *Antipodes*; Inhabitants, as I thought, with their Heads hanging downward: But now I am ſenſible what a Void there muſt have been, had not our Globe been habitable quite round. It would then have ſerved but juſt for half the Uſe it ſerves for now.

P. You do not know, *Matho*, that ſome Centuries ago it was reckoned abſurd, and little leſs than impious, to ſuppoſe that there were Antipodes, or Inhabitants on the oppoſite Part of our own Globe. This Narrowneſs of Thought is now laughed at as an idle Prejudice of ignorant Antiquity: But once it was a ſerious Affair. So difficult is it to get the better of Prejudices that have once taken Root in our Minds!

M. So much the earlier therefore they ought to be corrected. But in the preſent Caſe, I ſhall for the future contemplate the Face of the Heavens in the Night Time with more Delight, while I conſider that all above me is not a wild Solitude, deſigned only to fatigue the Eye, and amuſe us puny Mortals; but that rational Beings inhabit thoſe Regions, and admire with us the Wiſdom of the common Creator, diſplayed in their different Views of Nature: And

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while I reflect, that we have not paſſed the Bounds of the rational Creation, when without the narrow Limits of our own Syſtem.

P. You have ſeen how narrow the Limits of the Syſtem are, compared with the whole Creation: So that whatever Reaſon ſhews us that the Reſt of the Bodies in the ſolar Regions are not unfiniſhed or uninhabited Seats, muſt likewiſe ſhew us that the other Syſtems in the Univerſe (which bear an incomparably greater Proportion to them than they do to our Earth) cannot be an immenſe Deſert, nor be without Spectators of what is done there by the *Almighty Architect*.

M. I underſtand: The Reaſon becomes ſtill ſtronger the higher we aſcend.

P. If once we go beyond the Surface of this Globe on which we tread, we can ſtop no where; nor rebate the Force of the Reaſon, which ſtill becomes ſtronger, till we acknowledge the material Creation habitable throughout. Hence we muſt ſuppoſe that only a Point of the Univerſe is habitable; or that the whole Univerſe is habitable. The Argument will always return upon us, *Wherever that which was made*

made for the Sake of a nobler Nature is, there the nobler Nature for whoſe Sake it was made muſt be.

M. As was ſaid in a like Caſe before, it is probable the contrary Opinion firſt prevailed, becauſe Men believed that the Earth was the greateſt Body in Nature; that it occupied the Center of the Univerſe; that all Things elſe were created for its Sake; and that the Heavens conſiſted of ſolid Orbs, which whirled round our Globe in four and twenty Hours.

P. Let us only add to this, that an *univerſal upward* and *downward* was believed to reach through all the material World, reſpecting only this Earth; and I believe we have all the Prejudices on which the contrary Opinion was founded. So that whatever removes this Heap of vulgar Miſtakes from Philoſophy, and ſhews that the Earth revolves among the other Planets, and that its diurnal Rotation ſuperſedes the rapid Motion of the Spheres; ſhews at the ſame Time the Reaſonableneſs of this Opinion.

M. We ought therefore, I think, to come into it, in Conſequence of having thrown off thoſe Prejudices; unleſs we

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would be thought to have reformed our Philoſophy by halves only. And I am perſuaded, if we would but reflect that there is a *Downward* to other Bodies in Nature, as well as to our Earth; that alone would reconcile us to their being habitable Globes: But wherever a Body revolves about another as a Center, that ſhews a *Downward*. The Moon rolls about our Earth; from *thence* therefore to us is downward: The Moons of *Jupiter* and *Saturn* roll about thoſe Planets; whence there is a Tendency down to theſe alſo.

P. And that a much ſtronger Tendency than to this Globe.——In fine, *Matho* (for we muſt have done) it is of Importance to conſider here, that the Deity might, according to his Good-Pleaſure, have created more or fewer Worlds: But to have applied them when created to no Purpoſe, or to have repleniſhed one little Globe with rational Inhabitants, and left innumerable others empty and uſeleſs, is the perfect reverſe of Art and Contrivance.

M. That could only have been the Effect of Power undirected by Wiſdom.

P. And then upon Reflection you will find one Thing extremely remarkable. The Mind

Mind of Man itſelf only reſts ſatisfied with thoſe Effects of Almighty Power, the Greatneſs of which it can neither conceive nor ſearch out; and this whether we conſider the *Grandeur*, the *Number*, or the *Subtilty* of his Works. For as long as it can fathom ſomething farther, ſo long it conceives Omnipotence circumſcribed: And ſince this is a repugnant Thought, it reſts only ſatisfied when it can explore no Limits to Power and Contrivance. And in this ſingular View the Power of the Deity offers itſelf to be revered and adored by us! It was obſerved before, that we can ſee a little about *the Middle*; but could we reach to either of *the Extremes*, we ſhould find ourſelves diſappointed. The Mind would ſit down diſcontented, having nothing more to look for. As this is a Mark of Eternity (ſhall I call it?) in the Mind of Man; ſo what Richneſs of Power is it, that we can neither find out the Beginning, nor the End, nor the Extent, of the Works of God!

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M. What a noble View then of the material Creation have we from thence!

P. A quite different one certainly from that, which repreſents the celeſtial Orbs in-

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cloſing our Earth, as the *Shell* does the Kernel.

M. Name not that Diſgrace of Philoſophy. Here the boundleſs celeſtial Spaces, from Eaſt to Weſt, from the North to the declining South, are appointed for Life and Habitation; the *Seats* of Reaſon and (if I durſt ſo ſay) Humanity. I deſcry Worlds without Worlds; Suns and Syſtems, till the Imagination is wearied.

P. And there *Nature* and *Creation* begin anew, till the Creature ſinks in endeavouring to graſp the Works of the Creator.

M. This after all is a Work, this only a World worthy of the *Omnipotent Architect*, immenſely Good, immenſely Powerful!

CXXIX. *P.* But does not the Conſideration of theſe Things give you ſome Concern, *Matho*, leſt the Deity ſhould neglect you, having ſuch a Multiplicity of other more important Affairs to look after?

M. This, as I obſerved before, *Philon*, can give me no Concern; while I reflect and feel, that the conſtant Action of the Deity a thouſand Ways ſupports me. While I look or walk, while I ſpeak or think, my corporeal Frame is preſerved by innumerable

concurring Actions of Coheſion, Gravity, Repulſe, in every Part of my Body: Nay while I ſleep or breathe, and have not my Thoughts at my own Command, the Deity powerfully ſupports me. But why ſhould the Multiplicity of Affairs perplex the Deity? That only belongs to a limited Power. Did we ſee from the ſtrongeſt Reaſons that his Power, Wiſdom, and Goodneſs are infinite, only to forget the Conſequences of that Concluſion, when we had Occaſion to refer to them? Ninth Conference.

P. It is ſurely as you ſay, *Matho*; every Pulſe of the Artery, every Draught of Air we fetch, every Motion and Change of material Parts we feel in our Bodies, is a Pledge of the preſent Power and Kindneſs of the Creator; ſo that he is no leſs powerful and good to us, than if he were powerful and good to us alone, and to no other Beings. And then, as you obſerve farther, ſince it is the Property only of limited Power and Knowledge, to be perplexed and confuſed with the Multitude of Buſineſs, it would be fooliſh enough to fancy that the Deity might be over-powered in exerting his Power, or confuſed with the Extent of his own Knowledge.

M. Such

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M. Such Notions are inconſiſtent, and deſtroy themſelves. And from thence we may with Pleaſure infer, that we cannot conſider the Multiplicity of the Works of the Deity, as the Effect of his infinite Power; but we muſt at the ſame Time be ſenſible of our own Security, how ſmall a Part of them ſoever we may be.

P. So little inconſiſtent indeed are theſe two, that the Care for *the whole* conſiſts in a minute and conſtant Support of *all the Parts.*

M. But pray, *Philon*, inform me here, how our Bodies are conſtantly preſerved from the cruſhing Weight of the incumbent Atmoſphere, by the Particles of Air in all their Parts? This you mentioned in great Hurry juſt at our laſt parting.

P. I will not recommend that Notion to you (though it is the only thing that gives me Satisfaction in this Particular) and it was for that Reaſon I mentioned it in ſuch Haſte: However I ſhall tell you in few Words what ſeems right to me; and you may chooſe, or reject it afterwards, as it ſhall appear reaſonable to you on Reflection. No human Force or Induſtry can bring the Particles of Air into Contact; hence the Spring

Spring or repulſive Force of the leaſt Particle muſt be of itſelf ſufficient to bear off the Weight of the whole. Ninth Conference.

M. I conceive a Quantity of Air then, as conſiſting of a Number of ſmall Atoms, which ſuddenly ſtart from one another, if at any Time they have been ſqueezed into leſs Room.

P. You are right; when the Air is ſtrongly compreſſed, the Effort it makes to reſtore itſelf is incredible. Heat increaſes the repellent Force of the Air, and generates no ſmall Quantity of it, as we may ſee by the Vapour and Steam forced out from all combuſtible Bodies while they burn: From burning Gun-powder eſpecially great Quantities of Air are produced. From this Increaſe of the Spring of the Air by Heat, and the new Quantities of it produced, proceeds that fierce Exploſion, which throws out the Bomb, or Cannon-ball with ſuch Violence.

M. In this manner may *Ætna*, or *Veſuvius*, rage by the ſame Force.

P. And the Earth itſelf tremble too.—Now ſince Air may be generated from other Subſtances, by Heat, or by Fermentation, it ſeems perfectly needleſs to enquire ſolicitouſly how it can get into all the Parts of

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our Bodies by external Conveyance; or to place the whole Streſs of the Queſtion in the formal manner how that can be effected. It was conſtantly in all Parts of them, as being generated inwardly; and the Quantity of it, ſufficient to balance the Weight of the external Atmoſphere, can never be wanting. Nothing elſe could ſave us from being cruſhed, unleſs we ſhould call in the Help of a conſtant Miracle. This itſelf, I allow, is a conſtant Miracle: But then it is in the Courſe of Nature, and according to the Methods which we reckon commonly mechanical.

M. I underſtand pretty well what you ſay; but ſomething ſtill ſticks with me for want of farther Information. What is the Weight with which you reckon the Atmoſphere conſtantly preſſes us?

P. Since it preſſes us on all Sides, the Weight muſt be as the Surface it acts againſt. One Man may ſupport a Weight as ten Tun, and another fifteen, or even twenty. But if a Man were ſqueezed by half of this on one Side, it would preſs him to Death in a Moment.

M. Why could not the internal Air in all Parts of his Body balance this Weight?

P. Becauſe

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P. Becauſe it would have nothing to act againſt on the other Side. The Weight of the internal Air may be but a few Grains: This could never balance a Weight of ten or fifteen Tuns. But as ſoon as the Atmoſphere acts on the other Side, the internal Air by its repulſive Power defends itſelf in the Middle, and keeps off the Preſſure on each Side; ſo that we feel the Preſſure no more than if there were none.

M. I begin now to have a Notion of it. I fancied that the Preſſure on the one Side might balance the preſſure on the other; or that the external Air formed a ſort of *hollow Caſe*, as it were, round the Body, which ſupported, or kept off the Weight. But now I ſee the repellent Force of the Particles muſt puſh them to act on all Sides.

P. While we blow up *Soap-Bubbles*, which was mentioned before, into a ſpherical Figure, we are not to imagine that the external Air forms itſelf into a hollow Sphere, which ſuſpends the Weight of the Atmoſphere from acting on the Sides of the included Bubble; though a ſpherical Figure be allowed to be the moſt advantageous for ſuch a Purpoſe. If it were ſo, conſider what prodigious Force it would require to blow

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blow up the Bubble, and thereby to form this hollow Sphere, or ſuſpend the Preſſure of the Atmoſphere on all Sides of it. This ſhews us that it is the internal, or included Air, which (by its Spring) performs this Effect. And if this be ſo in a ſpherical Figure, it muſt be more ſo in any other Figure leſs regular.

M. You have entirely ſatisfied me on this Head, *Philon.* When I reflect on the various Shapes of all ſorts of Animals, and their conſtant Change of Figure while they move, the external Air cannot conſtantly throw itſelf into *hollow Caſes* to keep off the Preſſure of the Atmoſphere from their Bodies. —— But what was it you ſaid, when we parted, of People that dive under Water?

P. The Water muſt preſs them on all Sides, and that in Proportion to the Depth they dive to; nor can any thing defend them, in my Judgment, but the Spring of the Particles of Air in all Parts of their Bodies: For the Water being an unelaſtick Fluid, or having no repellent Force between its Particles, is leſs fit than the Air to form itſelf into ſuch ambient Figures, as might defend their Bodies from the Preſſure. If this were

ſo,

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ſo, it muſt defend them in all Depths alike: But the farther they go down, they feel the greater Pain in their Heads, Eyes, and Arms; according as the Spring of the internal Air is more over-powered.

M. Why do you ſay that no human Force could bring the Particles of Air into Contact?

P. In the greateſt Degree of Compreſſion Men can give the Air, Bodies move up and down in it without a Reſiſtance ſenſibly greater than ordinary. If the Particles of Air could be brought into Contact, it muſt probably be as denſe, and therefore as heavy as Water.

M. I remember indeed what you ſaid, of breathing a fluid as denſe as Water, when you firſt mentioned to me *a repulſive Force.*

P. Now I hope we have done.

M. We muſt rather return back to our Subject concerning the Planets; for

CXXX. There are ſtill two or three Particulars I ſhould be glad to have your Thoughts of; and eſpecially with regard to one I aſked about ſome Time ago; namely, Since a ſkilful Artiſt does nothing at Random, or without Deſign, pray what do

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do you take to be the Cauſe of the great Difference we find in the Revolution of the Planets on their Axis? *Jupiter*, the largeſt of them, performs more than two Revolutions on his Axis, before *Mars*, or our Earth, though much inferior to him in Bulk, performs one.

P. It is as true on the one Side, *Matho*, that the great *Architect of Nature* does nothing at Random, or without Deſign, as it is on the other, that we cannot diſcover the Reaſons in every Particular, why he hath contrived Things ſo; and this we muſt readily own, if we conſider the infinite Difference between his Knowledge and ours.

M. This is a ſatisfactory Reaſon enough why we cannot know every thing; or rather indeed, why we can know but few Things.

P. You ſee it is not an Excuſe contrived for our Ignorance, but a Truth flowing from the Limitation of our Knowledge, when compared with the Divine Intellect: Neither is it a Refuge deviſed to ſkreen the Works of the Deity from Enquiry and Examination. The better qualified any Perſon is to enquire into, and judge of theſe Works, ſo much

much the more Art and Skill will he find diſplayed in them. Ninth Conference.

M. All this is a plain Conſequence of what has been ſo often ſaid before.

P. To be ſatisfied therefore that the Divine Art reaches beyond our Faculties, is a negative ſort of Knowledge, as neceſſary to be kept in Mind, as any thing we know moſt perfectly: And hence, if we would enquire ſoberly into the Works of Nature, we ought humbly to adore, and reverence a Knowledge ſuperior to our own, even in thoſe things, where we can neither comprehend the *End*, nor the *Means* conducing to it; for this alſo belongs to ſound Philoſophy. Otherwiſe, if once we ſhould imagine we were capable of knowing every thing, we muſt neceſſarily fall into the Abſurdity of ſuppoſing there can be no Reaſon for ordering things ſo, becauſe we do not ſee the Reaſon.

M. That would indeed be direct Folly and Madneſs.

P. Much leſs ought we ſo rigidly to inſiſt on a Reaſon for every thing, as to leave nothing to the Determination of the Good-Pleaſure and Will of the Deity; in ſuch Caſes namely, where the *End* admits of a diverſity of *Means* equally conducive to

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it in Nature. For ſome Philoſophers have idly contended, That the Frame of Nature could not ſubſiſt, if the diurnal Revolution of the Earth, for Inſtance, were but a Minute, or half a Minute, longer or ſhorter than it is. They demand a ſufficient Reaſon for every *Hair's Breadth*; otherwiſe the Hands of the Creator muſt be bound up: As if his Good-pleaſure were not really the moſt ſufficient Reaſon in ſuch Caſes.

M. This is manifeſtly abſurd, and contrary to common Senſe at firſt Sight. Thoſe affectedly nice Folks, under Pretence of demanding a Reaſon for Things in themſelves indifferent, ſeem rather determined, I think, to bring the Deity under Reſtraints at their Pleaſure, contrary to Reaſon. But in the preſent Queſtion concerning the different Length of the Revolutions of the ſeveral Planets on their Axes, that is, concerning the different Length of the Days in each of them, may we not ſuppoſe that the Convenience and Pleaſure of their ſeveral Inhabitants is ſtudied? For in the Planets, which are at the greateſt Diſtance from the Sun, the Comfort of the Inhabitants ſeems to require that the Darkneſs ſhould be ſhorter, and the Returns of Light more frequent,

than in thoſe which are nearer the Center of the Syſtem. Thus *Mars* and our Earth, whoſe diurnal Revolutions are nearly equal, ſeem to have but the ſame Diſtance, if compared with *Saturn* or *Jupiter*.

P. We may ſafely ſay in general, *Matho*, that the Convenience and Comfort of the Inhabitants is the End of all thoſe ſtudied Contrivances which are obſervable throughout the whole Syſtem: But it would be raſh to be too particular in the Application of this general Concluſion; becauſe we may be too liable to fall into the Miſtake of meaſuring Conveniencies according to our own Conſtitution on this Globe: Whereas the Nature and Condition of the ſeveral Inhabitants, is probably as different as the Globe they reſide upon. We have Inſtances enough of this Diverſity of animal Life on our own Planet, to ſatisfy us that ſuch a Notion is not without Foundation. The *Ruſſian* Bear could as little live on the ſcorched Plains of *Africa* as the Lion or Tiger among the *Lapland* Snows. Some Creatures we obſerved ſleep for whole Months together: The quick Returns of Light and Darkneſs do not ſo much affect thoſe, as the ſlower Viciſſitudes of Summer and Win-

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ter. Some Creatures fly abroad only in the Dark, or charm us with their Muſick then, while others are repoſed in Silence at the ſame Seaſon.

M. This indeed I ſaw before: And among Vegetables likewiſe, ſome are fitted to thrive beſt in a cold Clime, whilſt others require a warmer Region; ſome are of a ſhort Duration, ſome preſerve their Verdure all the Year round; ſome appear early in the Spring, others later, through all Seaſons of the Year. There is, I perceive, an inexpreſſible Variety of Conſtitution both in the vegetable and animal Nature; ſo that I am obliged to you for reminding me of theſe Particulars on this Occaſion. We are apt to require thoſe Circumſtances every where, which ſeem moſt convenient to our own Condition: Though it muſt be as abſurd to imagine that all Things muſt be alike in the ſeveral Planets, as in all the Climes of the ſame Planet.

P. Agreeably to this therefore we ſee, there is a great Diverſity in their Revolutions on their Axes: *Mars* and our Earth perform their diurnal Rotation, as you obſerved, nearly in the ſame Time; but *Venus* and our Moon take a much longer Space;

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Space; the Day in *Venus* being 23 of our Days, and in the Moon a whole ſynodical Month; while *Jupiter*'s Revolution is performed in leſs than ten Hours, and *Saturn*'s probably is not of much longer Duration. Hence, beſides the Convenience you mentioned of the more frequent Returns of Light, another Advantage muſt accrue to the Inhabitants of thoſe larger Planets, by their ſwift Rotation on their Axes.

M. What other Advantage?

CXXXI. *P.* The Gravity of Bodies on the Surface of *Jupiter* is twice as great nearly as on the Surface of our Earth. Wherefore if we reſided on that Planet, we ſhould be a Burthen to ourſelves, being preſſed down with double the preſent Weight, and having but once the Strength to ſupport it. But *Jupiter* is more than ten Times larger in Circumference than the Earth: Hence if both Planets revolved on their Axes in the ſame Time, the centrifugal Force in *Jupiter* would be more than ten Times greater than with us. But the Squares of their periodical Times are nearly as 6 and 1; or the Squares of the Number of Revolutions performed in the ſame

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Time by the Earth and *Jupiter* are as 1 and 6. Wherefore a Body placed on *Jupiter* will have 60 Times a greater centrifugal Force than with us: Which muſt be a notable Relief to the Inhabitants of that Planet, although perhaps endued with a greater Degree of Strength than we are.

M. This is an Advantage I did not attend to. And what Part of their whole Weight may it be, of which they are thus eaſed by the centrifugal Force of their Planet?

P. They are lighter by about a ninth Part of their whole Weight: Or a Body weighing nine Stone at *Jupiter*'s Equator, if the Planet ſtood ſtill, would gravitate with a Force but as eight Stone, upon the Commencement of its diurnal Rotation.

M. That muſt in Truth be a great Relief. But as *Jupiter* is ten Times larger in Circumference than the Earth, why is not the Attraction, or Weight of Bodies, ten Times greater likewiſe on his Surface than on our Globe?

P. If the Matter in him were as denſe as in our Earth, the Weight of Bodies on their Surfaces would be as their Semi-diameters, or the Diſtances from their Centers:

ters: But the Matter in *Jupiter* ſeems to be made leſs denſe with Deſign. For we can hardly imagine that Men of our Stature, for Inſtance, could ſupport ten Times the Weight of ſuch Bodies as ours are, with Eaſe; or have the free Command of Limbs ſo chained down by their own Gravity. And if we ſuppoſe them of a larger Stature, the Inconvenience becomes greater, the leaſt of any Species being always obſerved to have the greateſt Eaſe and Agility in Motion. And upon the ſame Account, though *Saturn* be 8 Times larger in Circumference than our Earth, equal Bodies are not 8 Times heavier on his Surface than on the Surface of this Globe; but in the Proportion of 17 to 10; that is, not much above once and a half as heavy.

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M. I am almoſt fully perſuaded that this is a wiſe Contrivance of the Creator, for the Eaſe of the Inhabitants and Animals reſiding on thoſe Planets.——But is it certain that Bodies gravitate but twice as much only on the Surface of *Jupiter*, as on our Earth? For this I look upon to be a Point of Importance.

P. It is certain they do not gravitate quite twice as much there as here; but in

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ſuch Caſes I chooſe to give you the neareſt whole Number to expreſs the Proportion; becauſe where nothing depends on it, it is needleſs to trouble you with fractional Expreſſions, or the decimal Part of an Unit.

M. If it be practicable, pray make me underſtand this.

P. We are both of us already fatigued.

M. I ſhall leave you immediately after.

P. The Reaſon of the Thing is eaſily ſhewn: But a Calculation would be tedious.

M. The Reaſon of the Thing, with an eaſy Example to illuſtrate it, is all I deſire of you.——

P. Firſt then, Bodies attract at equal Diſtances according to their Quantities of Matter; a Body having double or triple the Quantity of Matter attracts twice or thrice as ſtrongly at the ſame Diſtance, as a Body having but a half or a third Part the Matter.

M. This is plain enough.

P. If therefore two Satellites revolved about *Jupiter* and our Earth, at equal Diſtances from their Centers; the Forces with which they were attracted would be as the

the Quantities of Matter in *Jupiter* and the Earth reſpectively. Ninth Conference.

M. That is but the ſame Thing in other Words.

P. Their centrifugal Forces likewiſe (which you know are always equal to the centripetal) ſhould be as the Quantities of Matter in the two central Bodies.

M. That comes ſtill to the ſame Thing.

P. The Squares of the Number of Revolutions, performed by theſe Satellites in the ſame Time, ſhould alſo be as their centrifugal Forces.

M. This you ſhewed me to Satisfaction before. And the Squares of the periodical Times are inverſely as the Squares of the Number of Revolutions performed in the ſame Time: For in the Example of our two Moons, the periodical Time of the outer Moon was 8 Times longer than the periodical Time of the *inner*; therefore the Number of the Revolutions of the inner Moon was 8 Times greater, ſo that 64 was the Square both of the one and the other.

P. From this then it follows, that the Quantity of Matter in *Jupiter* will be to the Quantity of Matter in the Earth, as the Square of the periodical Time of the

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Earth's Moon is to the Square of the periodical Time of *Jupiter*'s Moon revolving at the ſame Diſtance from him.

M. I perceive all the Steps in this Argument very diſtinctly; —— but none of *Jupiter*'s Moons perhaps revolve at the ſame Diſtance from his Center, as our Moon does from the Center of the Earth.

P. Our Moon you know is 60 Semi-diameters of the Earth from its Center: Now you may eaſily find out in what Time a Satellite would revolve about *Jupiter* at the ſame Diſtance from his Center; ſince the Cubes of the Diſtances are as the Squares of the periodical Times.

M. I muſt ſuppoſe then that a Satellite revolves about *Jupiter* at that Diſtance; and find the Time of its Revolution by this Proportion?

P. You muſt; and it is eaſily done: For taking *Jupiter*'s innermoſt Satellite, *v. gr.* whoſe Diſtance from his Center is about 55 Semi-diameters of our Earth, and its periodical Time 42 Hours 28 Minutes, or 2548 Minutes; ſay, as the Cube of the Diſtance 55 is to the Cube of the Diſtance 60, ſo is the Square of 2548 Minutes to a fourth Number, which will be the Square

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of the periodical Time of a Satellite revolving at 60 Semi-diameters of our Earth from the Center of *Jupiter*. This Number you will find to be about 8428776. The periodical Time of our Moon is 27 Days, 7 Hours, 43 Minutes, or 39343 Minutes, whoſe Square is 1547871649. Thus the Matter in *Jupiter* will be to the Matter in the Earth as 1547871649 to 8428776; or as 184 to 1.

M. This I ſhall try as accurately as I am able; —— But what is all this to Bodies gravitating only twice as much on the Surface of *Jupiter* as on our Earth?

P. If *Jupiter* were as denſe as this Earth, he muſt have a 1000 Times more Matter than is in the Earth, becauſe Globes equally denſe are as the Cubes of their Diameters; 10 and 1, to wit, in this Caſe. And ſince the Attraction increaſes as the Cubes of the Diameters, or Matter; but decreaſes as the Squares of the Diameters, or Diſtances; his Attraction on his Surface ſhould be as a 1000 divided by a 100; or as 10 and the Earth's as 1. But his Matter is only 184: Therefore the Attraction on his Surface is only as 184 divided by 100; and the Earth's as 1. That is, the

Attraction

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Attraction on his Surface is not twice the Attraction on our Globe.

M. It could not be twice as great, unleſs the Matter in him were 200 Times as much as in the Earth; for then 200 divided by the Square of the Diameter [100] would only be 2, while the Earth's was as 1.

P. You are very right.

M. And what is his Denſity with Reſpect to the Earth's?

P. Although his Matter were 200 Times as much as that in the Earth, he takes up a 1000 Times the Space, with only 200 Times the Matter. Divide the Matter 200 by the Space a 1000; and you ſee even then he would be 5 Times rarer than the Earth; or have but a fifth Part of its Denſity.

M. Well, I am extremely pleaſed with all this; and am now fully perſuaded that this Rareneſs of Contexture in thoſe larger Planets was wiſely deſigned for the Sake of Inhabitants reſiding upon them, who otherwiſe muſt have been oppreſſed by their own Weight. —— In what Time would this other Satellite revolve about *Jupiter*, at

at the Distance of 60 Semi-diameters of the Earth from his Center?

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P. The Matter in *Jupiter* is the Square of the Number of Revolutions it would perform, while our Moon revolves once about the Earth: And the Square Root of 184 is 13, 5. It must therefore revolve 13 Times and a half about *Jupiter* in the Time of our periodical Month. Or the Square Root of the other Number 8428776, *viz.* 2903, 2 is the periodical Time of this Satellite in Minutes; which comes to 48 Hours 23 Minutes.

M. I think I now understand enough to initiate me into these Calculations: Wherefore I shall not give you any farther Trouble at present.

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As the Weight of Bodies on the leſſer Planets is but ſmall, their Rotation on their Axes is ſlow, and their centrifugal Force but weak. Heat and Light are diſpenſed rather according to the Surface, than the Quantity of Matter in the luminous Body; hence the Sun is but of a moderate Denſity. That the uttermoſt and innermoſt of the Planets are not uninhabitable by Reaſon of the Extremities of Heat or Cold. Heat is not always in Proportion to our Vicinity to the Sun: Cold requires a poſitive Cauſe, or ſomething more than the mere Abſence of Heat. The Extremities of both may be qualified by the Conſtitution of an Atmoſphere. That all the Planets are ſurrounded with Atmoſpheres. The phyſical Explication how Bodies may deſcribe elliptical Orbits about an attracting Body, placed either in the Center of the Ellipſis,

Ellipſis, or in one of its Foci; according as the Law of Attraction is ſuppoſed different. Theſe two Caſes compared between themſelves, and the Tranſitions from the one to the other ſhewn natural and eaſy. The Proportion between the Squares of the periodical Times and Cubes of the middle Diſtances, ſtill obſerved when Bodies revolve in Ellipſes. The Comets revolve by the ſame Laws, and obſerve the ſame Proportions as the Planets.——Of the Immortality of the Soul. That the Soul is not aſſiſted to think and perceive by Organs of a dead Subſtance; but is by theſe confined and limited to a particular Manner of Action and Perception. Whether the Deity could cut off rational Beings, for whoſe ſake the material World was created; the Frame itſelf ſtill remaining. The Deſire of Exiſtence the Foundation of all our other Deſires, and the Source of all great and virtuous Actions. A happy Exiſtence the only Object of Deſire in the Nature of Things. Utter Extinction no Object of Deſire. The Diſingenuity of the Atheiſt: The Miſtake of thoſe who ſeparate Virtue from a Love to ourſelves. Atheiſts could not live together in Society

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on their own Principles. The falſe reaſoning in Mr. Bayle's *Apology for the Atheiſts. The Atheiſts Account of the Riſe of Religion. The Wonders in the material Creation deſigned to inſtruct Beings appointed for Immortality. The material Creation the inferior, and leaſt wonderful Part of the Works of God.*

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CXXXII. *M.* YOU ſee me here once more, *Philon*; and to begin where we left off ——

P. You begin abruptly enough, I think, *Matho.*

M. There is no need of reſuming what was ſaid laſt. I underſtand it tolerably well; nor would I deceive my ſelf in a thing of this Nature. —— I am much in Love with what you told me concerning the Quantity of Matter, and Denſity of the Planets, as alſo concerning their centrifugal Force, while they turn round on their Axes. But what is the Reaſon that we cannot find out the Quantity of Matter in *Mars* or *Venus*, as we do in *Saturn* or *Jupiter?* This, I remember, you ſaid was not known.

P. The Reaſon is, becauſe they have no Satellite (none conſpicuous to us I mean) revolving

revolving about them. Had they Satellites revolving about them, whoſe Diſtances and periodical Times were known, we could diſcover in what Time a Satellite ſhould revolve about either of them, at any aſſigned Diſtance; and thereby compare their Quantities of Matter, and Denſities with thoſe of any other Body in the Syſtem. Tenth Conference.

M. Of any other primary Planet, you mean, which hath a Satellite revolving about it?

P. That I ought to have ſaid.

M. Then we cannot know the Weight of Bodies on their Surfaces; nor compare *that* with their centrifugal Forces?

P. We cannot; though the centrifugal Force on *Mars* muſt be conſiderably leſs than on our Earth, both becauſe his Rotation on his Axis is ſomewhat ſlower, and his Diameter is much ſhorter; and on *Venus* the centrifugal Force is quite inconſiderable: But then, as theſe are only ſmall Planets, the Weight of Bodies upon them cannot be very great. In *Venus* it may be nearly the ſame as on this Globe; and were we on *Mars*, we could not feel much above half our preſent Weight.

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M. It was reaſonable that the centrifugal Force ſhould be ſmall, where the Weight was otherwiſe tolerable: For I now ſee that, the more ſwiftly any Planet revolves on its Axis, the more the Weight of Bodies upon it muſt be diminiſhed.

P. Undoubtedly: For theſe two Forces act contrary to each other in this Caſe, as much as in the Revolution of Planets round the Sun; ſince the centrifugal Force of Bodies proceeds from the Inertia of Matter, by which they always tend to move on in the ſame Direction.

M. But in the Revolution of Planets round the Sun theſe two Forces were in Equilibrio.

P. The Reaſon of that, you remember, is, leſt the Planets ſhould be drawn down to the Sun, or run out to a greater Diſtance from him; as the one or the other of theſe Forces prevailed: Whereas, had they been in Equilibrio here, Bodies would not at all have gravitated to their proper Center. Not only our Bodies would not firmly have participated of the Earth's diurnal Rotation, but our Houſes muſt have been looſe and tottering, or in conſtant Suſpenſe betwixt ſtanding and falling (for it is not eaſy to imagine

imagine the Caſe exactly); nor could the Ground itſelf have been a firm Support and Foundation for any thing. Tenth Conference.

M. I perceive ſomething here which I cannot well expreſs.

P. Nor can I underſtand it, unleſs you expreſs it in ſome Way or other.

M. It was as neceſſary that the centripetal Force ſhould prevail over the centrifugal, with reſpect to the diurnal Rotation; and that in a different Degree, according to the different Weight of Bodies on the larger and leſſer Planets; as that *theſe Forces* ſhould balance each other with reſpect to the annual Revolution: And in both Caſes we ſee them wiſely adjuſted in great Variety of Circumſtances. In ſhort, it is new Matter of Admiration, to ſee the centrifugal Force weak where the Gravitation is ſmall, and ſtrong, where the Weight of Bodies becomes greater.

P. The Obſervation is juſt; and the Expreſſion at leaſt intelligible.——

M. But in what Time muſt our Earth have turned round on its Axis, ſo as to have made theſe two Forces equal?

P. The centrifugal Force at the Equator (where it is greateſt) is to the centripetal as

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as 1 to 289. The Square-Root of this Number 289 is 17.

M. Pray let me go on with the reſt of the Argument by myſelf. —— Since the centrifugal Force is increaſed with the Square of the Number of Revolutions performed in the ſame Time; if the Earth performed 17 Revolutions in the Time it performs one, the centrifugal Force at the Equator would have been 289 times greater than it is at preſent, and therefore equal to the Weight of Bodies there, which conſequently muſt have been in conſtant Suſpenſe between flying off from the Earth, and remaining on its Surface: So that a ſmall Force muſt have given them a Motion to any Side, juſt as if they had been quite without Gravity.

P. You deduce the Argument very accurately.

M. But pray what would be the Conſequence, if the Earth rolled round a little more ſwiftly than at the rate of 17 Revolutions in 24 Hours?

P. From what you have ſaid juſt now it follows, that all Bodies at the Equator would then be thrown off from the Surface Eaſtward: But by the Action of Gravity retracting them, they would fall back again

to

to the Earth. And thus they would conſtantly be caſt off and fall back without ceaſing; nor could any thing be firmly ſettled in one Place, but as it lay nearer the Poles, where the Rotation was leſs violent. Tenth Conference.

M. This would be a wild Confuſion for a habitable Globe!——But let me recollect a little.——

CXXXIII. Seventeen Revolutions in twenty-four Hours is, I think, one Revolution in leſs than an Hour and a half.

P. It is one Revolution in an Hour and about 25 Minutes.

M. Then, as it appears to me, you argued inconſiſtently before, when we were ſpeaking of the diurnal Rotation of the Earth, where you ſuppoſed that it might turn round on its Axis every quarter of an Hour; ſince in that Caſe every thing muſt be thrown off from its Surface with inconceivable Rapidity: Or rather the whole Maſs would be ſhaken quite aſunder, except perhaps a ſmall Quantity about the Axis of its Motion.

P. You urge the Conſequence very well; the whole Maſs would then be ſhaken quite looſe: Notwithſtanding I have a right to

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make that Suppoſition, becauſe you know it is equally poſſible, that the Gravity of Bodies ſhould be augmented, as that the diurnal Rotation of the Earth might be accelerated, and that to any Degree; for it belongs equally to the ſame Power to effect a Change in either. The Suppoſition was therefore conſiſtent enough, and proper to the Subject we were then diſcourſing upon. For in that Caſe you could leſs have perceived the Motion of the Earth by the Help of your Senſes, than at preſent; ſince the Heavens and heavenly Bodies muſt have appeared to roll over our Heads weſt-ward, with greater Velocity than a Bird flies.

M. I underſtand; *That Suppoſition is conſiſtent, which does not imply a natural Impoſſibility.* And your Argument was as if you had ſaid, "Had it pleaſed the Almighty "Creator, ſo to increaſe the Gravity of Bo-"dies, and accelerate the Earth's diurnal "Rotation, that it ſhould have rolled round "on its Axis in ſuch a Time." —— After this pleaſe to ſhew me in what Time *Jupiter* muſt have rolled round on his Axis, ſo that the centrifugal Force of Bodies on his Surface might have been equal to their Weight or Gravity?

P. This

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P. This you ought now to find out for yourſelf, ſince you have the Diſtance and periodical Time of his innermoſt Satellite.

M. It is true; for I have already half of my Work done in the laſt Example. Then, ſince Bodies on *Jupiter*'s Surface are 10 Semi-Diameters of our Earth diſtant from his Center; it will be, as the Cube of 55 to the Cube of 10; ſo the Square of 42 Hours 28 Minutes, or of 2548 Minutes, to a fourth Number, which muſt be the Square of *Jupiter*'s periodical Time on his Axis, that Bodies on his Surface might have their Gravity and centrifugal Force equal. Or it will be as 166375 to 1000, ſo 6492304 to a fourth Number.

P. Which fourth Number you will find to be 39022; and the Square-Root of 39022 is 197, 5 Minutes; or 3 Hours 17 Minutes.

M. What is the exact Time of *Jupiter*'s Revolution on his Axis at preſent?

P. Nine Hours 56 Minutes.

M. *Jupiter* then performs but three Revolutions for one, that Bodies on his Surface may have their centrifugal and centripetal Forces equal; whereas our Earth ſhould perform 17 Revolutions for one.

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P. The Reaſon of which is, becauſe a great Part of the Gravity of Bodies on the Surface of *Jupiter* is taken off, by his ſwift Rotation at preſent.

M. Right. I ſee now that a ninth Part of their whole Gravity is taken off by their preſent centrifugal Force, as you told me before; or the centrifugal Force is but 9 times greater, when the whole Gravity is taken off; ſince it is as the Squares of the Number of Revolutions performed in the ſame Time, 3 and 1.

P. You have it exactly.

M. From this then I now alſo underſtand more clearly, what we have once or twice touched upon before; namely, why the Earth is higher about the Equator, and more flat and ſunk about the polar Regions; which Inequality ought, I think, to be more remarkable in *Jupiter*.

P. What are your Thoughts of that Particular now?

M. From the greater centrifugal Force about the equatorial Parts, the Matter there is relatively lighter; and is therefore more raiſed to make an Equilibrium.

P. The Inference is juſt; and on our Earth the Matter of Fact is confirmed both

by

by Meaſuring and other Experiments: But on *Jupiter*, whoſe diurnal Rotation is ſwifter, and the centrifugal Force therefore greater, the Inequality, as you obſerve, is ſtill more plain. For whereas in the Earth the equatorial Diameter exceeds the polar, but by one 230th Part of itſelf, or they are as 230 to 229; in *Jupiter* they are to each other as 11 to 10 nearly.

M. That is a notable Difference, and agrees well to his centrifugal Force.

P. The Difference is almoſt as great as the whole Diameter of the Earth, which is but about a 10th Part of *Jupiter*'s.

M. Here again, I think, ſomething is naturally ſuggeſted to us.

P. What?

M. That the Planets were firſt formed, and made ſpherical by the mutual Attraction of their Parts, before they received their diurnal Rotation: For this Riſing, or Swelling, about the Equator ſeems naturally to have been induced on a former ſpherical Figure.

P. It muſt indeed appear ſo to us in the Order of Nature.

M. Since then we muſt conceive the Planets as firſt without their diurnal Motion,

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tion, we may with Pleaſure ſee, as it were, this Rotation impreſſed on thoſe prodigious Globes, by the Almighty Hand of the Creator.

P. I agree with you. One, who conſiders Things in this philoſophical View, will feel all the Pleaſure you mention, in thus tracing the Original of the diurnal Rotation. And it appears ſomewhat inartificial firſt to ſuppoſe that the Deity moulded the Planets into this oblate ſpheroidical Figure (as it is called); and that then he impreſſed a Motion upon them which muſt of itſelf naturally have produced that Figure. For, as you well obſerved in our fourth Conference, the Attraction of Gravitation leaves Matter ſtill in the moſt fluid Form poſſible: So that a Body once brought into a ſpherical Figure, by this Affection between all its Particles, muſt neceſſarily, by a Rotation on an Axis, be elevated about the Equator of its Motion, and thereby become an oblate Spheroid.

CXXXIV. *M.* Pray what may the Weight of Bodies be on the Surface of our Moon?

P. If

P. If the Earth and Moon were of the ſame Denſity, Bodies there could have little more than a fourth Part the Weight they have here, according to the Diameters of the two Planets. But becauſe of the greater Denſity of the Moon, the Gravity of Bodies on the Earth is to the Gravity on her Surface as 293 to 100: That is, were we there we could not feel much above the third Part of our preſent Weight.

M. Much centrifugal Force on that Planet then muſt have been, I think, inconvenient, as rendering Bodies too light. — After this it would be needleſs to aſk what the Weight of Bodies might be on the Surface of the Sun, ſince he cannot be ſuppoſed habitable; and the Gravitation of Bodies muſt be exceſſively great, ſo near the Center of Attraction of the whole Syſtem.

P. It is not ſo great as you may imagine, *Matho:* Heat and Light are diſpenſed rather according to the Surface than the Denſity of the Body, or the Quantity of Matter in it. Hence the Sun is not one of the denſeſt Bodies of the Syſtem. And the Gravity on his Surface is reckoned but about

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about 24 Times more than that on the Surface of the Earth.

M. I ſee it is reaſonable that the Light ſhed round, and perhaps the Heat too, ſhould rather be as the Surface of the luminous Body, than as its Denſity; but I had quite other Notions of the Attraction or Gravity ſo near the central Body: Make me underſtand therefore, if you pleaſe, how this ſhould be?

P. The Quantity of Matter and Denſity in the Sun is diſcovered the ſame Way as the Quantity of Matter and Denſity in *Jupiter*; namely, by computing in what Time our Moon would revolve about the Earth, at the ſame Diſtance from it as *Venus* is from the Sun. —— As to the Denſity of Bodies, and Gravity on their Surfaces, you may perhaps get an eaſy general Notion of theſe, by conſidering the two following Caſes as *Extremes*. If the Matter in the Sun and Planets were as the Cubes of their Diameters, they muſt all have the ſame Denſity, and the Weight of Bodies on their Surfaces muſt be directly as their Diameters: For the Attraction increaſing as the Matter or Cubes of the Diameters, and decreaſing as the Squares of their Dia-

meters, the Cube divided by the Square would always give the Diameter to repreſent the Attraction of the Surface. Tenth Conference.

M. This was obſerved before.

P. But if the Matter were only as the Squares of the Diameters, the Denſity would be inverſely as the Diameters; and the Weight of Bodies would be the ſame on the Surface of all Planets, let their Quantities of Matter be ever ſo unequal.

M. I underſtand nothing at all of this.

P. Suppoſe there are two Planets whoſe Diameters are 1 and 10; and if, in Order to find out their Denſities, you divide the Matter (which is as the Square of the Diameter) by the Space it takes up (which is as the Cube of the Diameter), it will be 1 divided by 1, for the firſt Planet; and a 100 divided by a 1000, for the ſecond: Or their Denſities will be 1, and one tenth.

M. Thus far I ſee: The ſecond will have but one tenth the Denſity of the firſt, as its Diameter is ten Times larger. Thus if the Matter in *Jupiter* were but a 100 Times the Matter in the Earth, he ſhould have but a 10th Part of its Denſity, or be 10 Times more rare.

P. And

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P. And the Weight of Bodies on the Surfaces of all the Planets would then ſtill be the ſame: For the Attraction increaſing as the Matter, or Square of the Diameter, and decreaſing alſo as the Square of the Diameter, the Square of the Diameter *divided* by the Square of the Diameter will always be equal to Unity, how different ſoever the Diameters may be among themſelves.

M. Now you have given me Satisfaction; for I underſtand the Conſequence of both Suppoſitions, either when the Matter is as the Cubes, or as the Squares of the Diameters. And as any particular Inſtance, draws near to the one or the other of theſe Caſes (which you call *Extremes*) the Gravity on the Surface of that Planet will be more or leſs accordingly.

P. Both Caſes may be exemplified in one and the ſame Body, the Quantity of Matter in it remaining alſo the ſame; *only* by ſuppoſing its Diameter different.

M. Pray ſhew me how?

P. If the Diameter of the Sun be ſuppoſed a 100 Times the Diameter of the Earth, and the Quantity of Matter as the Cubes of their Diameters, their Denſities will

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will be equal, and the Weight of Bodies on their Surfaces directly as their Diameters: But if the Diameter of the Sun be ſuppoſed a 1000 Times the Diameter of the Earth, the ſame Quantity of Matter remaining, their Denſities will be inverſely as their Diameters, and the Weight of Bodies the ſame on both their Surfaces.

M. I conceive it: Though the Matter in the Sun be ſtill a million of Times more than the Matter in the Earth; in the firſt Suppoſition it is as the Cube of the Diameter a 100, and in the ſecond as the Square of the Diameter 1000: And the Surface of the Sun in the laſt Caſe being 10 Times farther from the Center, than in the firſt, the Attraction there will be a 100 Times leſs, or equal to the Attraction on the Surface of the Earth. This is agreeable enough, and gives me a more familiar Notion of theſe Things.

CXXXV. *P.* You ſee then by what artful Methods, of more or leſs Denſity, and more or leſs centrifugal Force, it comes to paſs, that the Weight of Bodies on the larger and leſſer Planets, is not near ſo different as the different Quantities of

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Matter in the Planets would ſeem to import?

M. I ſee every Thing in the Syſtem conſiſtent, if the Planets are conſidered with a View to *Habitation*; whereas without that, the Deſign ſeems broken and incoherent.

P. Eſpecially if we ſuppoſe the Earth alone deſigned to be habitable; while the Reſt are left ſolitary and unfrequented.—

M. Notwithſtanding there ſeems to remain ſtill one Inconvenience.

P. What is it?

M. That the Heat of the Sun cannot be multiplied at the Extremities of the Syſtem, by Reflection, as his Light is. The hundredth Part of our Heat muſt make *Saturn* but a comfortleſs Place.

P. As we ſaw before, *Matho*, that the animal Conſtitution, with Reſpect to Heat and Cold, may be widely different on the ſame Planet; ſo there may not be ſuch a Difference of the Degrees of Heat and Cold, on the Planets nearer to and more remote from the Sun, as we imagine. The Cauſes of Heat are more than one, as we may obſerve by what happens in the Bowels of the Earth, in *Fermentations*, in *Ebullitions*,

ballitions, even in our own Bodies; and eſpecially by common Fire. *Cold* likewiſe ſeems to imply ſomething more than a mere Privation of Heat, and to depend on ſome very active Principle. This will appear more probable, if we conſider the violent and ſudden Effects of Cold, in ſome common Experiments of artificial freezing; and when the Barrel of a Gun, or the Shell of a Bomb, though of conſiderable Thickneſs, is violently burſt by the freezing of the Water contained in it; that ſhews quite another Sort of Principle, than the mere *Inertia*, or Sluggiſhneſs of the Particles of Matter. The Rays of the Sun are certainly productive of Heat; but (by the Acceſſion, or Co-operation of ſome other Cauſe) not always in Proportion to their Denſity, or the Vicinity of the Body to the Sun: Otherwiſe we ſhould always have the ſame Degree of Heat or Cold, at the ſame Time of the Year, regularly in a Circle; which nevertheleſs you ſee we have not.

M. This is indeed common Experience, and ſeems to prove eaſily what you ſay. I have often obſerved very ſoft Weather, and mild Nights in the Depth of Winter, when a long Froſt has been ſucceeded by a quick

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Thaw; and contrarily, bitter Winds and a froſty Air, when the Sun has been near the Summer Solſtice.

P. This ſeems to proceed from the Conſtitution of our Atmoſphere, and the Alterations happening in it; which produce ſometimes ſultry Heat, and ſometimes piercing Cold, directly contrary to what ſhould be the Effect of the Sun's Rays ſeparately conſidered: So that *Heat* and *Cold* do not abſolutely depend on a Planet's Nearneſs to, or Diſtance from the Sun, but together with theſe, on ſome other Cauſes. We are conſiderably farther from the Sun in the Summer Months, than in the Winter, and for all that our Weather then is generally much warmer. —— Now, though *Saturn* has but about the hundredth Part of the Sun's Heat which we feel, I am not ſure if the hundredth Part of our Heat will amount to any Degree of poſitive and real Cold, without the Co-efficiency of ſome other poſitive and real Cauſe. And it is not difficult, I think, to conceive, that the Conſtitution of his Atmoſphere may be ſuch, as to make that Planet a mild and temperate Clime. And if there be any Weight in this reaſoning, it will not be hard

hard to apply it to the inferior Planets, *Mercury* and *Venus*; for we ſometimes feel the Heat of our Summer as much qualified by ſome different Cauſe, as the Rigour of our Winter.

M. There is indeed ſo much Reaſon in all this, that at leaſt I ſhall not be ſo raſh in drawing Inferences from narrow Principles in this Affair, as otherwiſe I ſhould have been. One Thing notwithſtanding ſurprizes me; *viz.* why the Earth ſhould be farther from the Sun at one Time than another: But before I aſk you concerning this Particular, I beg you would tell me, why you ſuppoſe there is ſuch an Atmoſphere about each of the Planets, as about our Earth?

P. I muſt ſuppoſe there is an Atmoſphere about every one of the Planets, unleſs I would imagine them to be Globes of Adamant, or ſomething ſtill more hard. Every Thing about our Earth is in conſtant Change: I am not certain if we can except any Species of Bodies that can be named. Metals themſelves ſeem gradually to decay, as well as come to a State of Maturity. Every Thing therefore contributes its Share to the Atmoſphere, which is an

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heterogeneous Mixture of all Sorts of Particles. Thus, unleſs we would ſuppoſe that the Matter in the Planets is not acted upon in the ſame Manner as the Matter in our Earth; which would be a Suppoſition without Foundation, and contrary to Reaſon; we muſt conceive that they have Atmoſpheres about them, like to that which is about the Earth. A Degree of Repulſe (leſs or more) is the Principle of Diſſolution of all natural Bodies, if we may ſpeak mechanically on this Head, and without conſidering the immaterial Cauſe of this Repulſe: And repellent Particles are moſt fit to join themſelves with the Atmoſphere, and to become a Part of it. It is this Principle which occaſions what is called *Effluvia* from particular Bodies: And the Effluvia of the Planets (if I might be allowed ſo to ſpeak) conſtitute their Atmoſphere.

M. I am afraid you are going too deep with me, though hitherto, I think, I underſtand what you ſay with Pleaſure: But what I meant by my Queſtion was, Whether the Atmoſpheres of the Planets can be diſcerned by Obſervation?

P. It is not neceſſary to the Conſtitution of an Atmoſphere that it ſhould have viſible

ble Clouds, and thick palpable Fogs: Our Atmoſphere exiſts no leſs when the Air is ſerene and clear, than when it is heavy and clouded. It is obſerved that the higheſt of the Clouds, when their Height is meaſured, are not found to reach above a Mile from the Surface of the Earth: But allowing them to be two or three Miles high; what is that to the Diſtance of the Planets? To ſuppoſe that Obſervation might determine here, is to ſuppoſe the Object within the due Diſtance; which is the Miſtake in ſeveral other Caſes. Our Atmoſphere, how high ſoever, tranſmits the Light of the fixed Stars to us, as you obſerved before: And if we may reaſon from Analogy, the Atmoſphere of other Planets ſhould do the ſame. Beſides, as far as Obſervation can reach, both our Moon and *Mars* are diſcovered to have Atmoſpheres: In the Appulſes of *Mars* to the fixed Stars, they are obſerved to become obſcure and dim; and in total Eclipſes of the Sun, the Moon's Atmoſphere becomes perceptible.

M. It ſeems indeed, wherever there is Heat and Moiſture there muſt be Vapours; and conſequently an Atmoſphere.

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P. Nay, wherever there is Cold there muſt be an Atmoſphere; for Vapours are obſerved to riſe plentifully in the hardeſt Froſt.

CXXXVI. *M.* Pray tell me now, if it be true that we are nearer the Sun in the Winter than in the Summer; how comes it to paſs that we feel ſo much more Cold when nearer him, than when farther diſtant from him?

P. You ſhould have propoſed this Difficulty, *Matho*, long ago; for when you ſuppoſed that our Diſtance from the Sun was always the ſame, you ſhould either have aſked this Queſtion then, or inferred, becauſe we were equally near the Sun, Summer and Winter, that we muſt have had the ſame Degree of Cold all the Year round.

M. I'm afraid my Queſtion is not ſo much to the Purpoſe as I imagined.

P. It is obvious that the Rays *falling* more or leſs obliquely on the Surface of the Earth muſt occaſion a great Difference in the Degrees of Heat. Hence it muſt be leſs when the Sun ariſes but a little above our Horizon in the Winter, than when he mounts higher, and darts his Rays more perpen-

perpendicularly upon us. You find when you hold any Thing directly oppoſite to the Fire, it is more ſtrongly heated, than when you turn it ſide-wiſe at the ſame Diſtance. Tenth Conference.

M. I perceive it muſt be ſo: But in what Proportion will this oblique Incidence of the Sun's Rays increaſe or diminiſh the Heat, the Diſtance being the ſame?

P. I am not ſure if the Proportion which ſeems juſt to me will appear ſo to another.

M. Tell it me however: A Gueſs ſometimes helps us to come nearer the Truth afterwards.

P. 'Till you can come at ſomething more authentick then, you may ſuppoſe that the Denſity of the Rays, and therefore the Degree of Heat, will be as that Line which is called the *verſed Sine* of their Inclination, or Angle of Incidence.

M. Shew me this by a Figure?

P. You may ſee it from any Circle. In this Figure, if the Sun be perpendicular over the Plane, the Rays will be the denſeſt poſſible at that Diſtance; and their Denſity may be expreſſed by the Radius. But if the Sun be in this Poſition (ſuppoſe 32 Degrees from the Vertex) drawing a Line

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from him to the Center, none of the Rays on the upper Side of the Line, you ſee, will fall upon the Radius, and thoſe only on the under Side are now ſpread over it all. But theſe are only the Rays which fell upon *this Part* of it, when the Sun was vertical; which Part is the verſed Sine of the Angle of Incidence of the Rays.

M. So it appears indeed from the Inſpection of this Figure: And at this Rate what may be the Proportion of our Heat in Winter to that in Summer?

P. If this Proportion be juſt, abſtracting from the Difference of Diſtance, and all other Cauſes of Heat, except the Denſity of the Rays, our Heat in Winter will be about the ſix and twentieth Part of what it is in Summer. For ſuppoſing our Latitude 55 Degrees and a half, the Sun's greateſt Altitude in Summer will be 58 Degrees, and in Winter only 11; the verſed Sines of theſe are 4849619 and 183728, which are nearly as 26 and 1.

M. All this I underſtand, and am ſatisfied that the ſix and twentieth Part of our Summer's Heat is no Degree of Cold: For it is ſtill Heat perceptible to Senſe. And how great may our Heat in Summer be, with

with Reſpect to the Heat at the Equator, when the Sun is vertical to them?

P. Our Heat muſt be about half of theirs; for the verſed Sine of 58 Degrees is ſomewhat leſs than half the Radius.

M. This Proportion will farther ſhew us the Denſity of the Sun's Rays at any Time of the Day, as well as any Time of the Year, according to his Altitude?

P. If it be juſt in the one Caſe it muſt be ſo in the other.

M. I ſee no Objection againſt the Juſtneſs of it, at preſent; and even though it ſhould not be preciſely juſt, thus much ſeems certain, that another Cauſe mixes itſelf with the Effects of *Heat* and *Cold*, beſides the greater or leſs Denſity of the Sun's Rays, or even his total Abſence. —— Now, as to the Earth's being at a greater Diſtance from the Sun, in Summer than in Winter; if this be ſo, I know not what to ſay. I thought a Body could not have revolved about the Sun in any other than a circular Orbit, without being drawn down to him, or running out through the celeſtial Spaces; and this Notion you ſeemed to approve of: This ſtumbles me exceedingly.

P. In

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P. In all ſuch Subjects, *Matho*, People generally begin, you know, with the eaſieſt Caſes: To tell them of more intricate and difficult Things at firſt would only tend to diſcourage them. And that is the ſimpleſt Caſe of one Body's revolving about another, by the Compoſition of an attractive and projectile Force, when it moves in a circular Orbit. As this Caſe is plain, you eaſily conceived it: Yet it is no leſs true that a Body may deſcribe about another an *oblong* or *elliptical Orbit*. This is more difficult to be conceived, but it no Way invalidates the Truth of what you already know. The Orbits of the Planets are not exactly circular, yet they differ not much from real Circles, having but a ſmall Degree of Excentricity. This Method was intended, not to ſtumble you, but for your more eaſy Conception.

M. You ſatisfy me as to the Reaſonableneſs of the Method, which I ought to leave entirely to you; if it were poſſible to obſerve a Method in ſuch a looſe Diſcourſe, where ſo many Things offer accidentally. But can I be made to underſtand how a Body may deſcribe an oblong or elliptical Orbit about another, without falling quite down

down to it, or running out through the ambient Space? Tenth Conference.

P. Not perfectly, I am afraid. It will require too many Words, and many childiſh Suppoſitions. Great Men underſtand this in their own ſuperior Way, without accommodating themſelves to our Conceptions.

M. An imperfect Notion is better than none at all. The more childiſh your Suppoſitions are, the more they will ſuit my Capacity: And as for Words, I told you, I often diſcourſe for whole Hours together, without any other Advantage than having got rid of ſo much Time. And at worſt, as we are by ourſelves, there can be no Harm in making a Trial, though it ſhould prove unſucceſsful.

P. Well, on theſe Terms we may make a Trial: It will be but a little Labour loſt.——

CXXXVII. But before we begin, it will be neceſſary to acquaint you with ſome general Things concerning the *Ellipſis*. Here is the Figure itſelf. It is deſcribed about two Points, as the Circle is about one. Theſe Points (marked with the Letters

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ters F and f) are called its *Foci*. As theſe Points may ſtill recede farther from, or draw nearer to the middle Point, or Center C, the Ellipſis may be more or leſs oblong, that is, more or leſs eccentrical, 'till it becomes a *ſtraight Line* on the one Extreme, or coincides with a Circle on the other.

M. This is plain enough; for I have ſeen Carpenters draw ſuch Figures on the Floor, about two Pins, with a double Cord and a Piece of Chalk, when they were going to make an *oval Table*: And we have ſometimes diverted ourſelves in drawing the like Figures, when the Workmen were gone.

P. Then your Diverſion will prove a Means to facilitate the Matter to you now. Theſe two Lines, which croſs each other in the Center at right Angles, are the *greater* and *leſſer* Axis. If the Attraction be to the middle Point, or Center, when the Body, moving in the Perimeter of the Ellipſis, comes to the Extremity of the leſſer Axis here, it will be at the neareſt Diſtance to the central Body; and at either Extreme of the greater Axis, the fartheſt from it. But if the Attraction be to this *under Focus* F, when the revolving Body comes

comes to the Extremity of the leſſer Axis, it is ſaid to be at the middle Diſtance from the attracting Body: For from the Focus to the Extremity of the leſſer Axis, is a *Mean* between the greateſt Diſtance, when the revolving Body is in the *upper Vertex* (or fartheſt Extremity of the greater Axis) and the leaſt Diſtance, when it is in this *nearer Vertex*.

M. Let me conſider a little this laſt Particular. — The middle Diſtance then muſt be equal to half the greater Axis: For if I add the Eccentricity to half the greater Axis, that makes the greateſt Diſtance from this *lower Focus*; and if I take away the ſame Eccentricity from half this Axis, that makes the leaſt Diſtance.

P. You are perfectly right. And this is all that is neceſſary to trouble you with at preſent.

M. Theſe Particulars I can eaſily remember. But ſomething you inſinuated in your Deſcription of the Ellipſis appears quite ſtrange, and is more than I expected.

P. What was it?

M. That a Body may move in the Perimeter of an Ellipſis, by the Compoſition of an attractive and projectile Force, either when

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when the attracting Body is in the Center of the Ellipſis, or in one of its Foci.

P. The revolving Body muſt deſcribe an elliptical Orbit, as well in the one Caſe as in the other, according as the Law of Attraction is ſuppoſed different; which perhaps you may underſtand hereafter, if I can hit upon an eaſy Way of communicating theſe Things to you.

M. I am to the laſt Degree impatient to hear this: For, if I might ſpeak my preſent Sentiments, the Thing ſeems to me utterly impoſſible.

P. In the mean Time it would not be amiſs to acquaint you with another Particular, though it be not abſolutely neceſſary; and I am afraid it may be difficult too.

M. Pray tell it me at a Venture: The more preparatory Things I have, the more eaſily I ſhall underſtand what follows.

P. If a Body revolve about a Center, by the Compoſition of an attractive and projectile Force, and if a Line from the Center to the Body be ſuppoſed to move along with the Body, that Line will ſweep, or run over, equal Spaces in equal Times.

M. You

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M. You mean, if we ſuppoſe the Time divided into Minutes, or ſmall Portions, the Line in any Minute will ſweep over a triangular Space, which will be equal to the triangular Space it runs over in any other Minute?

P. That is the Thing.

M. So far then I think I underſtand, that if a Body be ſuppoſed to move along a right Line with an equable Celerity, if we take any Point without that Line, and imagine Lines drawn from that Point to the Body, at the end of equal Times, the Triangles muſt all be equal, as having equal Baſes and the ſame Height.

P. Then you have got over the Difficulty of this noble Theorem; for it is founded upon what you have ſaid.

M. Could you ſhew me a Figure to help me a little?

P. Here is a large, intelligible Figure; and the Thing explained in Words.

M. Let me read and conſider this.

P. Don't be in a Hurry; but go through the Argument at Leiſure: You are under no Obligation to underſtand theſe Matters at firſt Glance. ——

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M. What I have hitherto ſeen is not difficult. —— I think I conceive the whole. It depends on two eaſy Propoſitions in *Euclid*: And as to the Body's moving in the Diagonal of a Parallelogram, when urged by two different Forces, I make a ſhift to underſtand that from what you ſhewed me concerning the Frog carried along the Diagonal of a Square, by the Compoſition of its own Motion with the Motion of the Plane. On the ſame Account it muſt have been carried along the Diagonal of a Parallelogram by a little Change of the Direction and Velocity of the two compounding Motions.

P. I find you really underſtand it; however conſider it over again: We get larger and firmer Notions of any thing by a ſecond Examination of Particulars. ——

M. I fancy I underſtand it tolerably well, and am glad I beſtowed the little Pains on *Euclid* which I did, when I find the eaſieſt Things in that Book aſſiſt me to make out theſe Matters. This encourages me to be more diligent. —— I ſee there is no begging of any thing here; one is forced to own that the revolving Body muſt neceſſarily deſcribe equal Areas in equal Times, by Rays drawn

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from the Center to it; and that it muſt move in a Curve, if we divide the Time in very ſmall Parts, and make the Triangles very narrow; ſince the attractive Force acts inceſſantly. —— This is delightful! I ſee, if the revolving Body ſhould be brought nearer the Center, it muſt neceſſarily be carried about with more Celerity, that the Swiftneſs of the Motion may compenſate the Smalneſs of the Diſtance, in order to deſcribe as large an Area in an equal Time, as when it is farther off. And on the ſame Account, it muſt be carried more ſlowly when more remote; ſtill to preſerve the equable Deſcription of Areas.

P. Your Obſervations are very juſt, and natural: We need ſay no more on this Head.

M. Let me look at the Book a little, before I return it. —— This is Sir *Iſaac Newton*'s own Book! Then I am not a little pleaſed with myſelf, that I have made out a Propoſition of this Great Man's, from his own Words. Here is his Picture: What a thoughtful Face is this! and how mild and ſweet too!

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CXXXVIII. *P.* Theſe Things premiſed, you muſt in the next Place obſerve that a Body thrown up perpendicularly to any Height, acquires the ſame Force and Velocity in falling back again, with which it was projected.

M. This muſt be the Caſe, I ſuppoſe, when I throw a Stone perpendicularly upward; it falls back in the ſame Track, and with the ſame Velocity.

P. The Reſiſtance of the Air may perhaps occaſion a ſmall Variation; otherwiſe the Maxim is in itſelf plain. For the Body receiving an equal Number of Impulſes from its Gravity in aſcending or deſcending, and thoſe equally ſtrong in equal Diſtances from the Center, whether it aſcends or deſcends; the laſt will reſtore to it all the Force and Velocity, which the firſt took from it.

M. This is not difficult to be conceived; for ſince *falling* (or moving to any Point) is not the Action of Body, more than *riſing* (or moving from that Point;) it muſt require an equal Force impreſſed, to make the ſame Quantity of inert Matter move through the ſame Space, whether toward, or from the Center.

P. And

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P. And ſince the Space is the ſame, and the Efficacy of the Cauſe the ſame in the ſame Diſtances, the Time muſt be the ſame alſo.

M. So I underſtood it. Therefore if a Stone were dropt from a Height, and thrown up again with the ſame Force it had acquired from the Impulſes of Gravity in falling, it would mount to the ſame Altitude from which it had firſt begun to deſcend: The Force it had acquired in falling would be ſpent in riſing, by the contrary Impulſes of Gravity, in the ſame Space and Time.

P. You are right: This is the ſame Caſe conſidered in a contrary View, or taken backward. And it will be equally true, whether we ſuppoſe the Body thrown up from the very Center of Attraction, and falling back to it, or from ſome Height above the Center, and falling back to that Height only.

M. The Reaſons already mentioned muſt be equally applicable to either of theſe Suppoſitions.

P. It muſt alſo be equally true, tho' the Body ſhould not be thrown perpendicularly upward, but with an Inclination to one Side; for if it riſe and fall through equal Spaces,

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it muſt loſe and acquire equal Forces, by the contrary and conſpiring Impulſes of Gravity in equal Times.

M. This is ſtill equally reaſonable. If I throw a Stone on plain Ground, ſo that it deſcend as far as it aſcended, it muſt have the ſame Force when it falls, as when it roſe. And if it were ſtruck back with the ſame Force it had in falling, it would, I conceive, return to me in the ſame Path.

P. Without doubt; for if you had thrown the Stone from that Part at firſt, with the ſame Force, and the ſame Degree of Elevation, it muſt have moved in the ſame Path, from the one Side, as well as from the other.

M. I have often obſerved in playing at *Shittle-Cock*, that it was becauſe we ſtruck it always with equal Force, and in the contrary Direction, that it deſcribed ſtill the ſame *Curve*, or *Arch* as it were, backward and forward, between each other's *Battledoor*.

P. The Example you bring is proper enough to aſſiſt the Imagination: And if a Stone, or any *Projectile* whatever, were ſtill thrown back with the ſame Velocity, and in the ſame Elevation, it would deſcribe the ſame Path exactly, forward and backward for ever.

M. This

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M. This Caſe where the Body is projected with a Degree of Elevation, may be brought, I think, to coincide with the former, where it is thrown directly upward. For if we ſuppoſe a plane to move equably along with an horizontal Motion, and a Body to be projected directly up from it; this Body to one not carried along with the moving Plane, will appear to be projected with a Degree of Elevation. Now if it be true with reſpect to the moving Plane, to which the Projection is perpendicular, that the Body hath an equal Force and Velocity at equal Heights, both in its riſing and falling; this will be equally true with reſpect to a Spectator off at a Side, who ſees the Body really deſcribe a Curve, or Arch. Here the Body is impelled by two Forces; one communicated to it by the Plane, with which it is equably carried along, and another by the Cauſe which gives it the perpendicular Projection upon that Plane. Theſe two Forces do not diſturb or confound each other; becauſe a Spectator carried along, ſees the undiſturbed Effect of the perpendicular Force; and an immoveable Spectator at a vaſt Diſtance above, would perceive the undiſturbed Effect of the horizontal Force. So when we throw a Body

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with a Degree of Elevation, the Force impreſſed upon it is equal to the Compoſition of two Forces, the one impelling it perpendicularly upward, and the other horizontally forward: And theſe two Forces no more diſturb each other's Effects, than if the Body had a plane moving equally along under it.

P. You aſſiſt yourſelf extremely well, *Matho*, in conceiving the ſeparate Effects of Forces thus compounded, which are wont to perplex us in the Beginning.

M. I thought your Suppoſition of *the moving Plane and the Frog* ſomewhat ludicrous at firſt; but I have found it very uſeful ſince.

P. But tell me, when you throw a Stone with a ſmall Degree of Inclination to one Side, what is the Reaſon that it does not go on in one uniform Direction, as when you throw it perpendicularly upward?

M. When I throw it perpendicularly upward, the projectile and attractive Forces act in the ſame ſtraight Line; ſo that there is no Force acting on any Side, to draw it out of this uniform ſtraight Direction: But when I give it the leaſt Degree of Inclination to one Side, theſe two Forces conſtantly act in different

different Directions, and the Body muſt conſtantly change the Direction of its Motion, or move in a Curve.

P. You will not retract this Conceſſion afterward?

M. It is a Conceſſion you can always force me to make.

CXXXIX. *P.* Keeping theſe Things in your Mind, conſider next how many different Curves, or *Arches* (as you call them) a Stone, or any Projectile, may deſcribe, by the attractive and projectile Forces acting together.

M. It may deſcribe very many certainly. If I throw a Stone perpendicularly up, it falls back in the ſame Line or Track. If I give it a ſmall Inclination to one Side, it deſcribes *an high and narrow Arch:* If I give it a little more Inclination, it will deſcribe *a lower, but wider Arch*; and ſo on. For I ſee there is no End of this Variety, ſo long as I can give it a different Inclination, and impreſs Force enough upon it, to make the Caſt different.

P. Where the Strength of your Arm fails, you may take into your Suppoſition a Bomb, or Cannon-Ball, diſcharged from

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a Piece of Ordnance; or ſomething as much above the Force of a Cannon-Ball, as that is above the Force of a Stone thrown by your Arm; or yet a Cauſe ſtill more powerful than that, *&c.*

M. I ſee where this muſt end. The Difference is only in *more* or *leſs*, and the Reaſon the ſame, 'till we come to the Projection of a Planet by the Almighty Arm.

P. Not ſo faſt: We are not there yet. —— What if you throw a Stone neither upward nor downward, but ſtraight forward, or in an horizontal Direction?

M. Only *one Side* of the *Arch* will be deſcribed; from the middle Point, or *Vertex*, to wit, which divides between the two Sides of the Curve.

P. What becomes of the other Side of the Arch?

M. That I cannot indeed tell. —— But ſtay: There muſt be ſomething under this Queſtion. —— If one ſtanding on a lower Ground where the Stone fell, ſhould ſo throw it back, that it returned to the Point from which I firſt projected it, with the ſame Force, ſo that it fell on a lower Place on the other Side of me; it would then deſcribe both Sides of the Arch. Whence

I ſee, it deſcribed but the Part of a Curve, the whole of which it muſt have deſcribed in proper Circumſtances.

P. I dare ſay, *Matho*, you have ſpoke better Senſe than you are aware of.

M. It may be ſo; but ſhew me how?

P. Without ſtaying to do that at preſent; are not both Sides of this Curve, from the vertical Point, equal and ſimilarly bent?

M. Certainly, when in both Suppoſitions the Stone moves from that Point with equal Force, though to oppoſite Sides: It cannot perform the one half of its Courſe in one Path, and the other in another.

P. Imagine now you projected the Stone with an Inclination below the horizontal Direction; and tell me what muſt follow then?

M. It would deſcribe only *a Piece of the Foot of the Arch*; the whole of which it would ſtill deſcribe backward, if returned with a proper Direction and Velocity.

P. It is ſo; the Curve would ſtill be completed, *i. e.* it would ſtill return upon itſelf, and be an entire Ellipſis, if it were not for ſome Obſtacle the Projectile meets with.

M. That

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M. That I do not ſee, for any Projectile of this Sort muſt ſtill meet with the Earth, which ſtops its Motion.

P. You will ſee it gradually, by going on; and in the Interim you muſt keep in Mind likewiſe theſe ſeveral Particulars.

M. I ſhall not readily forget them, ſince I ſee the Reaſons all along.

CXL. *P.* Suppoſe now, as you did in a former Caſe, that the Earth were perforated from us to the Antipodes, and that a Stone were thrown perpendicularly upward from the Center, with ſuch Force, as to reach 20 Yards above the Surface on this Side; I deſire to know how it would move after that?

M. It muſt fall back to the Center in the ſame Path, or ſtraight Line, as much as a Stone thrown perpendicularly upward by my Hand, falls back on its own Track.

P. Would it ſtop at the Center?

M. It could not; for having (agreeable to the Maxim we ſpoke of) regained the Velocity in deſcending, which it loſt in aſcending; that is, the Velocity it was firſt projected with; it would riſe 20 Yards above the oppoſite Surface, as neceſſarily as it did on

on this Side. And becauſe it could no more hang in the Air *there* than *here*, it would fall back to the Center again; and riſe to us again; and (which is ſtrange enough!) it would, I ſee, thus continue to move forward and backward for ever; acquiring ſtill the ſame Force and Velocity at the Center, by which it would riſe to the ſame Height here and there alternately. And ſtill in equal Times; for the Space being the ſame, and the Efficacy of the Cauſe the ſame in equal Diſtances from the Center, the Effect would be the ſame in every Reſpect.

P. All this is right enough. But imagine now that the Stone is thrown up, not from the Center, but from a Point off to one Side of it, and in a Direction parallel to the former, ſo that it ſhould ſtill riſe 20 Yards above the Surface; and in that Caſe how would it move?

M. You ſuppoſe now the Perforation ſo wide, that the Stone ſhould have free Paſſage all the Way?

P. I do.

M. It would then riſe to the Surface, with a ſmall Degree of Inclination towards the Perpendicular (becauſe now the projectile and attractive Forces do not act in the ſame Line).

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Line) and croſſing the Perpendicular at its Extremity, or the 20 Yards Height, it would fall back again to a Point as far on the other Side the Center, as that Point was whence it was firſt projected (for both Sides of its Path muſt be equal, and ſimilarly bent) deſcribing a very high and narrow Arch indeed! This is the ſame Caſe, differing only in *more* and *leſs* (as I ſaid) as when I throw a Stone with a ſmall Degree of Inclination, to the ſame Height, *viz.* of 20 Yards. And the two Curves ſhould coincide about the *Vertex*, or in the Part above the Surface, if the Stone projected from below came up to the Point whence mine began to move, with the ſame Degree of Inclination.

P. You ſee then in this Caſe that your Stone deſcribes but a Part of a Curve, the whole of which it would deſcribe in proper Circumſtances?

M. I begin in Truth to ſee a little into the whole Affair.

P. But ſhould the Stone, when it falls back to the Point you mentioned on the oppoſite Side of the Center, reſt there?

M. It could not; for (by Virtue of the *Maxim* ſtill) regaining the ſame Force there, as when firſt projected, and having a ſimilar Direction,

Direction, it ſhould mount up to the oppoſite Surface, and deſcribe the other End of the arched Figure, or Oval, *there*; as neceſſarily as it did the firſt End of it *here*. In a Word, for whatever Reaſon it deſcribed the firſt Half of the Ellipſis to our Side, for the ſame Reaſon it would deſcribe the other Half of it to the oppoſite Side, or complete the whole Revolution. Nor could it ſtop then, but having the firſt Force ſtill in that Point whence it was firſt projected, and the firſt Direction alſo, it muſt neceſſarily go through a *ſecond* Revolution, and a *third*, and ſo on, without ceaſing.

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P. You have gone round with the whole Revolution, *Matho*, ſo accurately, that you have left nothing to my Correction. I was particularly pleaſed to find you obſerve ſo opportunely, that when the two Forces, the *projectile* and *attractive*, act ever ſo little in different Directions, the Body could not move in a ſtraight Line.

M. As they conſtantly urge the projected Body in new Directions, it muſt inceſſantly change Direction, or move in a Curve; tho' that Curve draws near to a ſtraight Line; for I remembered that this was the Caſe where you ſaid, the Ellipſis approaches to a ſtraight

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a ſtraight Line on the one *Extreme*, as it may to a Circle on the *other*.

P. What are your Thoughts as to the *Time* of this Revolution?

M. Since the Body was projected with the Velocity to reach 20 Yards above the Surface, it muſt come to that Height in the ſame Time as if it had been projected from the Center. For I ſaw, from the Inſtance of the Body projected from the moving Plane, that the Effect of the one Force does not diſturb the Effect of the other: The perpendicular Force raiſes the Body to the ſame Height, in the ſame Time, as if the Plane did not move; and the horizontal Force carries the Body the ſame Length and in the ſame Time, as if the Plane only moved; or as if there were no perpendicular Force.

P. I am glad you have got over this Difficulty, which was wont to give Beginners the greateſt Trouble. But to return, If in any Point of this Ellipſis, the Stone were projected with the ſame Direction and Velocity, which it had in that Point, when it performed its firſt Revolution, will it not in this Caſe deſcribe the ſame individual Ellipſis ſtill?

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M. Certainly: It is this that makes the Neceſſity of its revolving conſtantly in the ſame Ellipſis, and that without End; becauſe, to wit, it has the ſame Velocity and Direction in every individual Point, as it had there at firſt. Or, the Velocity and Direction in any one Point is neceſſarily connected with the Velocity and Direction in every other Point throughout the whole Ellipſis. Hence the Projection may be made from any Point, if with the Direction and Force proper to that Point.

P. Let not this Reaſoning ſlip out of your Mind again.

M. I ſhall endeavour to remember it.—

P. But if the Stone were projected at a ſtill greater Diſtance off to a Side from the Center, ſtill in a parallel Direction to the perpendicular Projection, and with a Force to riſe to the ſame Height; What muſt enſue?

M. It muſt deſcribe a wider Ellipſis, but touching the former in the two *Vertices*; and the Time of the Revolution will be equal to that of the former. And the ſame Reaſoning ſtill holds, though the Diſtance of the Projection from the Center be ſuppoſed ſtill greater and greater, the other Conditions

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ditions remaining the ſame. Theſe Ellipſes will all touch in the Vertices, their Times will be equal, and the firſt perpendicular Projection will be a common Diameter to them all. For there is no End, I ſee, of the Variety of theſe Ellipſes, growing ſtill wider and wider.

P. You ſee in this firſt Caſe then, how poſſible it is that a Body may deſcribe an oblong or oval Figure, about a Center, by the Compoſition of two Forces, an attractive and a projectile?

M. I ſee, *Philon*, from this endleſs Variety of them, that I cannot throw a Stone in any Direction, but it muſt deſcribe a Part of an Ellipſis, the whole of which it would deſcribe about the Center of the Earth (if that were pervious;) and I can hardly find Words to expreſs my Satisfaction and Surpriſe, to find that ſo common and childiſh an Experiment, as throwing a Stone out of one's Hand, ſhould ſhew us the Truth of a Propoſition, which ſounds at firſt like an Impoſſibility. But upon Reflection, I ſee it muſt neceſſarily be ſo: It is this that makes a Stone, or any Projectile deſcribe ſo regularly a Part of this Figure, *here*, at the *Antipodes*, or in any Part round the Earth. In ſhort,

ſhort, the *Action* of *Falling*, which you ſo warmly recommended to my Obſervation at our firſt Interview, contains in itſelf the whole Myſtery of this Affair. The Body is always either falling, or riſing by the Impetus it hath acquired in deſcending, till that be ſpent; and then it is in the Circumſtance of deſcending anew. Tenth Conference.

CXLI. *P.* Let us ſtop here a little then, and look back: For it will not be amiſs to obſerve, that when the Stone is ſuppoſed to be projected perpendicularly upward from the Center, it muſt perform its Courſe backward and forward, or run twice over the whole Diameter of the Earth, in an Hour and about 25 Minutes. And a Revolution in any one of thoſe Ellipſes, whether narrow or wide, will (as you rightly obſerved) take up preciſely the ſame Time; till they become ſo wide, that the laſt of them coincides with a Circle at the Surface of the Earth.

M. You ſhewed me indeed a little before, that a Body muſt revolve at the Surface of the Earth in that Time; or performs 17 Revolutions in 24 Hours, that it may have a centrifugal Force equal to its Gravity.

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And now I ſee the Connexion, with Reſpect to the Equality of Time, all along through the intermediate Ellipſes, 'till we come to the perpendicular Projection through the Center.

P. You have thus a right Notion of this Matter: But you will be ſtill more ſurpriſed when I tell you, that, if a Body were projected from the Center but half way up to the Surface, or a 4th Part only, or an 8th Part, or even but a Mile; it would ſtill take up the ſame Time (an Hour and 25 Minutes) to perform its Courſe forward and backward; or to perform a Revolution in an Ellipſis, or Circle, deſcribed on any of theſe different Heights as a Diameter.

M. Would a Body take as much Time to riſe and fall through a Projection of a Mile's Height, as through one of 4000? Or to revolve in a Circle of 2 Miles Diameter, as in one of 8000 Miles Diameter?

P. Exactly the ſame Time, in this Caſe?

M. Shew me, I pray you, how this could be?

P. I ſhall endeavour to make you conceive it in ſome Meaſure, as it has Relation to what we are going to ſay. —— Firſt you muſt

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muſt know, if a Body were placed within a hollow Sphere of attracting Matter, it would remain wherever it were placed, without moving to any Side. For though it were placed nearer to one Side of this hollow Sphere than to the other, the Matter attracting it on the oppoſite Side would be as the Square of its greater Diſtance: So that the Attraction increaſing as much on account of the Matter, as it decreaſed on Account of the Diſtance, the Body would be in Equilibrio, wherever it were placed within the Sphere; or if it were ſet a moving, it would move on equably, without Acceleration.

M. This I think I have ſome Notion of; for if the Body were placed exactly in the Center, it could then move to no Side, being equally attracted to all Sides. And if it were removed from the Center, nearer to one Side, the Quantity of Matter it receded from, muſt be greater than the Quantity of Matter it approached to, and would therefore keep it in Suſpenſe.

P. It is greater in the Proportion I mentioned, which admits of an eaſy Proof, if it were worth the while to leave what we are upon at preſent for the ſake of that.

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M. You will ſhew me afterward where I may meet with this Proof; and in the mean Time pleaſe to go on.

P. If a Body then were placed on the Surface of the Earth, it would be attracted by all the Matter in the Globe: But if it were placed below the Surface (ſuppoſe a 1000 Miles) it could not be attracted by the Matter above that Height (for a 1000 Miles Thickneſs round about) more than if ſo much of the Globe were taken quite away.

M. I underſtand: The Body is, as if it were placed within a Cruſt of 1000 Miles Thickneſs, which could attract it no Way; or, it would only be affected by the Matter below that Depth.

P. And if it were 2000 Miles below the Surface, it could only be attracted by the remaining Matter of the Globe, and by none of the Matter within 2000 Miles of the Surface any where round.

M. This is but the ſame Caſe: I ſee, were the Body placed within a Mile of the Center, it would only be attracted, as if the Globe were but a Mile in Radius, all the Matter above that urging it no Way. But what follows from all this?

P. Where-

P. Wherefore in the perpendicular Descent of the Stone, the attractive Force you see is always as the Distance between it and the Center, or as the Space to be gone over. When the Space is twice as great, the accelerating Force is twice as great; when the Space is but a 4th Part, the Force is only a 4th Part. If the Space be but a Mile, or one 4000th Part, the Force will be exactly in that Proportion.

M. I am impatient for your Conclusion from this.

P. Whence, be the Space little or much, it must always be run over in the same Time; for twice the Space will be run over with twice the Celerity, in the same Time as half the Space with half the Celerity; or as a 4000th Part of the Space with a 4000th Part of the Celerity.

M. Let me consider this in my own Way.——

CXLII. When the attracting Globes are of equal Density, the Gravity on their Surfaces is as their Semi-diameters, or Distances from their Centers: Wherefore the Gravity to the Center, at any Depth in the Earth, must be as the Part of the Semi-diameter to

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be run over. Thus far is plain. —— I divide the whole Semi-diameter into a certain Number of Parts, and the half of it into the ſame Number of Parts: Any Part in the firſt Diviſion will be double any Part in the ſecond Diviſion; becauſe the Whole is double the Whole. This likewiſe is plain. —— The Attraction at the Surface, in the beginning of the Motion of two falling Bodies, is double the Attraction at half that Diſtance: Wherefore a Part of the firſt Diviſion will be run over in the ſame Time as a Part of the ſecond Diviſion, though the one Part be double the other. —— The upper Body has now double the Velocity of the under Body; it likewiſe receives a new Impulſe of Gravity doubly ſtronger than what the other receives: This will cauſe the next Part in either Diviſion to be run over in the ſame Time. It is ſo every where: The upper Body has always double the Velocity of the under Body, and receives every where a doubly ſtronger Impulſe to increaſe it in that Proportion. —— The Argument is the ſame, if I had ſuppoſed the lower Body to have but a third Part of the Semi-diameter to run over; the upper Body muſt in any Part of its Deſcent have had triple the

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the Velocity of the *lower*, and every where have received a triply ſtronger Impulſe, to maintain the Velocity in that Proportion.— Now, *Philon*, I am ſatisfied in this Particular with great Pleaſure. A Stone, when projected but a Mile up from the Center, muſt take as much Time in returning to the Center again, as when projected four thouſand Miles up, or to the very Surface.

P. This you have examined very minutely. You may likewiſe remember, when we were ſpeaking of the various Laws of Attraction, which the *Creator* might have inſtituted in our Syſtem, we mentioned *that*, where the centripetal Force, or Gravity, was ſuppoſed to increaſe as the Diſtance from the Center of Attraction; and the centrifugal Force, in order to balance it, was alſo to be increaſed as the Diſtance.

M. I remember the Caſe diſtinctly.

P. But in the preſent Caſe you ſee the Attraction is increaſed as the Diſtance of the Stone from the Center of the Earth: Therefore if it were to revolve about the Center of the Earth in Circles at different Diſtances; *ex. gr.* ſo that the Radius of an exterior Circle ſhould be twice the Radius of an *interior*; that it might have double the cen-

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trifugal Force in the exterior Circle, to balance the double centripetal Force, it muſt move with double the Celerity as in the interior Circle; and therefore perform a Revolution preciſely in the ſame Time.

M. Theſe were the very Conditions, and this the Concluſion the Matter was brought to: So that if this Law had obtained in the ſolar Syſtem, all the Planets (the uttermoſt *Saturn*, and the innermoſt *Mercury*) muſt have revolved about the Sun in the ſame Time exactly.

P. Hence therefore in the preſent Caſe, a Body would revolve about the Center of the Earth, in a Circle whoſe Radius were a Mile, or an hundred Miles, or a thouſand Miles, *&c.* all in the ſame Time. *viz.* an Hour and 25 Minutes.

M. This is extremely obliging, to ſhew me theſe agreeable Speculations as we go along.——

P. To bring what we have ſaid more within the Reach of being applied to our preſent Purpoſe, if we ſuppoſe that this were really the Law which obtained in the ſolar Syſtem——

M. Pray interrogate me on this Head, to ſee if I can give you proper Anſwers.

P. With

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P. With all my Heart. If this then were really the Law which obtained in the ſolar Syſtem, and if two Planets revolved about the Sun, the one at 4 times the Diſtance of the other, in what Proportion ſhould their Celerities be?

M. The Celerity of the *exterior* ought to be 4 times greater than the Celerity of the *interior*, to give it 4 times a greater centrifugal Force.

P. But if it were projected with more than 4 times the Celerity of the *interior*, what would enſue?

M. It could not then move in a circular Orbit, but would mount higher and deſcribe an Ellipſis about the Sun, equal Portions of which would lie to oppoſite Sides of the Sun; juſt as the Stone did about the Center of the Earth; for the Law of Attraction is now by Suppoſition, the ſame in both Caſes. As the Sun is placed in the Center of this Ellipſis, the revolving Body would be neareſt him when in the Extremity of the leſſer Axis. There it would move with the greateſt Celerity, as the Stone did in moving by the Center of the Earth. In the Extremity of the greater Axis its Celerity would be leaſt of all, that the *Areas deſcribed in equal Times might*

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might be equal: For thus it was with the Stone when it came up to the *Vertex* of its Curve.

P. What if the Planet were projected from the ſame Point with a ſtill greater Celerity?

M. It would mount higher above the Sun, or deſcribe a more oblong Ellipſis, which, as well as the former, would touch the circular Orbit in the Point of Projection, and in the Point oppoſite to that. And the ſame Reaſoning holds, if we ſhould ſuppoſe it projected ſtill with a greater Degree of Celerity, from the ſame Point always: Nor is there any End of the Variety here.

P. But is there no Hazard, if the Velocity with which the Body is projected be very great, of its flying out through the celeſtial Spaces, without returning again?

M. None at all: Let the Planet riſe ever ſo high, it muſt deſcend towards the Sun again, and deſcribe the other half of the Ellipſis to the oppoſite Side; ſince by Suppoſition the centripetal Force becomes the ſtronger, the greater the Diſtance is.

P. What would happen if the Projection were made from another Point exterior to the

the former, and with a greater Celerity than what would be ſufficient to make the Planet revolve in a Circle at that Diſtance?

M. It would deſcribe Ellipſes, ſtill riſing higher, the greater the projectile Celerity were ſuppoſed to be: All which Ellipſes would have the Sun for their common Center. And this Argument is equally applicable to any Point we can name: Nor is there any End to the Variety of Nature, and Bounds of Poſſibility; that is to the Extent of Omnipotence, which ſoon ſwallows up the Imagination.

P. But what do you ſay as to the periodical Times in all theſe infinite Ellipſes?

M. They would all be the ſame to a Minute. For if we ſuppoſe a Body to be projected perpendicularly up from the Sun to different Heights; ſince (as was ſaid before, with Reſpect to the Center of the Earth) the accelerating Forces are always as the Diſtances to be run over; it muſt always fall back in equal Times, though one Diſtance ſhould be a million of Times greater than another. And this is likewiſe true if theſe Diſtances be taken equal on the other Side of the Sun, or the ſeveral Lengths be made double. We have alſo

juſt

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juſt now ſeen that Planets revolving at all poſſible Diſtances from the Sun muſt, on this Suppoſition, perform their Periods in equal Times. But a ſtraight Line is the *extreme Ellipſis* on the decreaſing Side, as a Circle is on the increaſing: And when the Time in a ſtraight Line, and a Circle on that as a Diameter, is the ſame, it muſt be the ſame intermediate Ellipſis, whether wide or narrow.

P. You ſee then it muſt be as natural for a Planet on this Suppoſition, to deſcribe an elliptical Orbit about the Sun, as a circular one?

M. I ſee plainly the one is as natural as the other; which notwithſtanding, without this Deduction, I ſhould have thought a ſtrange Paradox.

CXLIII. *P.* After this, we have little more to do than to make the Tranſitions from one Law of Attraction to another: For if we next ſuppoſe that the Attraction is inverſely as the Squares of the Diſtances from the Center of the Sun (which is the Law you know that really obtains) you will ſee the Deviations from the former

Caſe to this, not at all unnatural, but ſuch as in Reaſon they ought to be. Tenth Conference.

M. So far you ſhewed me before, that both the periodical Times and Celerities of Bodies revolving according to this Law are different from what they were in the laſt Suppoſition; the Squares of the periodical Times being as the Cubes of the Diſtances, and the Celerities inverſely as the Square Roots of the Diſtances. It was thus that the *interior* of our two Moons had twice the Celerity of the *exterior*, which was at 4 Times the Diſtance, and but the 8th Part of her periodical Time.

P. Theſe Proportions aroſe from bringing the centrifugal Force into an Equilibrium with the centripetal, in the preſent Law of Attraction: The Foundation of the next Difference will appear more obvious, which is this. A Planet in the former Caſe ſtill returned toward the Sun again, though projected with a Velocity many Times greater than what was requiſite to make it move in a circular Orbit at that Diſtance; becauſe it met with the greater Reſiſtance the higher it mounted. But it muſt be quite otherwiſe here, where the Attraction

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Attraction decreaſes, as the Squares of the Diſtances increaſe.

M. I am aware of this; for the Body meeting with ſuch a haſty Decreaſe of Reſiſtance as it riſes, ſtill feels the greater Facility in aſcending; and this muſt neceſſarily have a very different Effect from the Caſe where it ſtill found the greater Difficulty. In ſuch Circumſtances, it is poſſible, I conceive, if the Body were projected with a great Exceſs of Velocity, above what would make it move in a circular Orbit at any aſſigned Diſtance, that it ſhould never turn down again, but move on towards the Region of the fixed Stars.

P. This is ſo poſſible, *Matho*, that if it were thrown up but with twice the Celerity requiſite to make it move in a Circle at the Point of Projection, it could never return towards the Sun, but run out through thoſe Spaces endleſly.

M. That makes the impreſſing the projectile Force in this Caſe an Affair of great Delicacy! But what is the leaſt Velocity, with which if a Body were projected, it could not deſcend again towards the Sun?

P. If the Velocity with which a Body would deſcribe a Circle at the Point of

Projection, be as unit, or 1, by a Velocity as 1, 4142, *&c.* it ſhould move in a Curve, which does not return upon itſelf, nor incloſe Space, but runs out ſtill to a greater Diſtance. Tenth Conference.

M. Then a Velocity, leſs than once and a half the circular Velocity, would throw the Planet quite off through the ambient Space?

P. It would. But if a Velocity as 1, 4142, would throw the Planet quite without the Syſtem, it muſt return if projected with any leſs Velocity.

M. I ſee it muſt, ſince the Velocity you name, is the leaſt that could throw it quite off; however, at this Rate it may return from a prodigious Height; for there is hardly any fixing a Limit betwixt a boundleſs Space, and the next inferior bounded Figure: So that a Planet might aſcend, I think, to as great a Height according to this Law of Attraction as the former, and ſtill return again: Only a much more ſkilful and meaſured Force of Projection is required *here* than in the laſt Caſe.

P. You expreſs the Difference of the Caſes extremely well: The attempering a ſmall Force (comparatively ſpeaking) has the ſame Effect here as the Application of a vaſt

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a vaſt Force there. However let us ſuppoſe that a Body is projected with a Velocity a little greater than 1 only, or (that we may ſpeak of ſomething definite), with a Velocity as 1, 15; and ſince a Velocity as 1 would make the Planet revolve in a circular Orbit at that Diſtance, a Velocity as 1, 15 muſt carry it higher. And you will conceive the whole Matter the more eaſily perhaps, if you imagine that the Body moves, as it were, in a Medium *denſer* nearer the Sun, but which becomes always *rarer*, as the Squares of the Diſtances, to which the Body riſes, becomes greater.

M. This indeed aſſiſts me. The decreaſe of Reſiſtance muſt have the ſame Effect upon the Motion of the Body, as a Medium growing rarer in the ſame Degree, though I otherwiſe ſee the Strength of your Argument: The Body muſt riſe higher from the Point of Projection, or mount above the circular Orbit, becauſe its Velocity is greater than 1; and yet it cannot fly quite off, becauſe its Velocity is leſs than 1, 4142.

P. Suppoſe then, the Body being projected with a Velocity as 1, 15, that a Diameter to the circular Orbit is drawn from the

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the Point of Projection, but produced indefinitely without that Orbit on the other Side; and then you will likewiſe ſee, that the Body thus projected, muſt come to croſs that Line at ſome Height or other, on the oppoſite Side of the Sun: Or, at leaſt, you will ſee ſome Objection, which hinders you from aſſenting to this.

M. I rather ſee the Neceſſity why it muſt be ſo; for I have the whole Scheme diſtinctly in my Imagination, and what you ſay ſhews me half the Ellipſis is already formed.——The projectile Direction at firſt was perpendicular to this Diameter; that is, the projectile and attracting Forces acted upon the Body at right Angles to each other: The Body, becauſe of its greater Velocity, began immediately to move without the circular Orbit: The two Forces acted then obliquely upon it, which made it deſcribe a Curve without the Circle: This Curve, ſince the Body could not fly off finally, muſt come to croſs the produced Diameter again, in the oppoſite *Vertex*, to wit; for the Diameter goes through the Center of the Sun: And then the Body has performed half its Revolution. This extended Diameter becomes the greater

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Axis of the Ellipſis: The Body was at the neareſt Diſtance to the Sun in the Point of Projection; and is at the greateſt Diſtance from him now in the other Extremity of the Axis. All the Time therefore from the Point of Projection to this Point, the Body has moved gradually with leſs Velocity, that the *Areas* it deſcribed in equal Times might be equal. Hence the projectile Force became more languid, as the Sun's attractive Force grew weaker. And theſe two Forces act now on the Body at right Angles again, in this remoter *Vertex*.

CXLIV. *P.* You have imagined the Caſe perfectly well, *Matho*, and according to Nature. The ſlower the Body moves, the attracting Force hath the more Time to act: Therefore it bends the Curve all along, 'till at length it acts again on the Body at right Angles to the projectile Direction, and by that Means hath more Efficacy. But how doth the Body move from that remoter *Vertex*?

M. Being now at its greateſt Height, it begins to return; and in deſcending its Velocity muſt be accelerated in the ſame Manner as it was retarded in aſcending, by the

Maxim

Maxim we ſpoke of: For the Attraction to the central Body, which in its Riſing hindered it, now conſpires with it, and is equally ſtrong in equal Diſtances. Hence it muſt deſcribe the other half of the Ellipſis, ſimilar and equal to the firſt, and in equal Times. For in returning, it comes as it were into a *denſer Medium*, and feels a ſtronger Retraction to the Center, and that inverſely as the Squares of the Diſtances; ſo that it cannot run out to an equal Height from the Sun on the other Side, as in the former Caſe; but returns to the Point from which it firſt ſet out, with the ſame Velocity, and in the ſame Direction. Whence it muſt perform a *ſecond* Revolution, and a *third*, and ſo on without End, by the ſame Neceſſity as it performed the *firſt*.

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P. You have prevented me here, *Matho*, in making one material Obſervation, which is, that whereas in the laſt Caſe, equal Halves of the Ellipſis lay on oppoſite Sides of the Sun, here, on the contrary, the greater Half of the Ellipſis lies on one Side.

M. I ſaw it was impoſſible that two ſuch contrary Laws of Attraction ſhould

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have the ſame Effect. In the former Caſe the Attraction was leaſt of all when the Body was neareſt the Center; therefore the Body paſſed on almoſt in the Direction of the projectile Force, as the Stone did when moving in a narrow Ellipſis about the Center of the Earth. But *here* the Attraction is ſtrongeſt of all, when the Body is neareſt the Center: Therefore it cannot paſs on, as in that Caſe, but muſt have its Direction moſt changed, or its Path moſt bent and incurvated in this Part. From hence I ſee the Truth of what you told me, *That the Deviations in this Caſe from the former, are ſuch as in Nature and Reaſon they ought to be.*——With Reſpect to this a Thought occurs to me, which I believe I cannot well expreſs to you, as it is yet but raw and undigeſted.

P. The Thought will come in View as you attempt to explain it.

M. If we ſuppoſe the Point of Projection to be the ſame, and the Velocity with which the Body is projected to be the ſame, in both theſe different Laws of Attraction; we ſhall more clearly ſee the Difference of the Effects, and the *Tranſition* from the one Caſe to the other.

P. I be-

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P. I believe indeed we may; go on therefore to compare them.

M. Suppoſing then the Point of Projection and Velocity the ſame; in the laſt Caſe, becauſe the Attraction is weakeſt neareſt the Sun, that is, at the Point of Projection, the Body will move forward almoſt in the ſame Direction; or, if we may borrow the *Points of the Compaſs*, to denominate the Situation of the Ellipſis, it will lie from *South* to *North*, for inſtance; and the circular Orbit, which the Planet would deſcribe at that Diſtance, will lie in the Middle of the Ellipſis; the Sun being in the common Center of both Curves. But in the preſent Caſe, becauſe the attracting Force is ſtrongeſt at the Point of Projection, where the Body is neareſt the Sun, the Curve will be moſt bent there; and the Body inſtead of going on in the Direction of the firſt projectile Impreſſion, will be ſtrongly drawn about; ſo that this Ellipſis will lie croſs the other, or extend from *Eaſt* to *Weſt*. The greater Axis of this Ellipſis will coincide with the ſhorter Axis of the former, but reach a great Way farther: For the Body here will riſe to a much greater Height, as having the ſame

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projectile Velocity, and meeting with much leſs Reſiſtance. Whence the preſent Ellipſis will be much larger, and the ſame circular Orbit at the Point of Projection, will lie in one End of it, touching it in the nearer *Vertex:* And the lower Focus of the Ellipſis, poſſeſſed by the Sun, will coincide with the Center of the Circle.

P. You have already attained a great Compaſs of Thought in theſe Matters, *Matho*, when you can purſue ſuch a complicated Suppoſition with ſo much Juſtneſs and Propriety. This familiarly explains to us how, in the preſent Caſe, the Ellipſis muſt lie unequally to oppoſite Sides of the Sun, and leaves no Room for farther Doubt.

M. I am ſatisfied with this myſelf, becauſe I underſtand what I ſay; which I confeſs is not always the Caſe.

P. To ſpeak ſo as to underſtand one's ſelf is no common Advantage; which we are not at all Times ſufficiently aware of. But farther,

CXLV. Since you ſee the Neceſſity that the Body in this Caſe muſt return to the Point whence it was firſt projected, with the

the ſame Velocity and Direction which it had there at firſt, and for that Reaſon perform a ſecond Revolution, and a third, *&c.* in the ſame Orbit; you will likewiſe ſee, if it were projected from any Point of the Ellipſis with the ſame Celerity and Direction, which it had in that Point in the firſt Revolution, that it muſt revolve in the ſame individual Orbit ſtill?

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M. I ſee the Neceſſity of this as much here as in the former Caſe; becauſe getting the ſame Celerity and Direction in any Point is the ſame Thing, as if the Body had been projected from the *firſt Point*, or *nearer Vertex* of the Ellipſis, and ſo come up to that Point with the requiſite Velocity and Direction. In ſhort, this is none of the Particulars in which the two Caſes differ.

P. In Order to deſcribe, or move in this Ellipſis therefore, you ſee the Planet might have been projected with a great Variety of Celerities and Directions, according to the Point it was firſt projected from?

M. I ſee that in every Point from the *nearer Vertex*, whence we ſuppoſed the Projection made, to the *higher Vertex*, the

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Celerity and Direction must have been different. For in the *lower Vertex* the Celerity was greateſt, and the Direction of the projectile Force was at right Angles to that of the attracting Force: From that Point to the *upper Vertex*, the Velocity grew always leſs, and the Direction of the two Forces became more oblique, till the Attraction began to bend the Curve towards the other Extremity of the Axis. From this I ſee it was the Conveniency of the Suppoſition, and not Neceſſity, that determined you to imagine the Projection made from the *lower Vertex*.

P. Moreover, becauſe the ſmall triangular Spaces, or *Areas*, deſcribed in equal Times, muſt be equal, you will conceive that the Celerity of the revolving Body muſt always be inverſely as its Diſtance from the central or attracting Body?

M. I conceive this eaſily; for equal Triangles have their Baſes inverſely as their Altitudes.

P. You likewiſe remember, when the revolving Body is at the Extremity of the *leſſer Axis*, it is in the middle Diſtance between the greateſt and the leaſt?

M. I re-

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M. I remember it; and that this middle Diſtance is equal to half the *greater Axis.*

P. The Body therefore at that Diſtance will have a *mean Velocity* between the greateſt and the leaſt?

M. It muſt; for ſince the Velocity decreaſes as the Diſtance is increaſed, when the Diſtance is half increaſed from the leaſt to the greateſt, the Velocity will be half decreaſed from the greateſt to the leaſt.

P. You expreſs it very well. —— But ſince the Velocity at the *lower Vertex* is greater than the Velocity in a Circle at that Diſtance from the Focus, and the Velocity in the *upper Vertex* is leſs than the Velocity in a Circle at that Diſtance, the mean Velocity will be equal to the circular Velocity at the middle Diſtance?

M. So it ſeems; for in paſſing from a Velocity greater than the circular, to a Velocity that is leſs, the Body at the middle Diſtance muſt move with a Velocity equal to the circular Velocity at that Diſtance.

P. Since then the Velocity at this Point is equal to the Velocity of a Body moving in a Circle at that Diſtance, and ſince the Deſcription of *Areas* is equable to both in the

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the Ellipſis and Circle, the whole *Elliptical Area* will be run over by a *Ray* paſſing from the Body to the Focus, in the ſame Time as the whole Area of a Circle, whoſe Radius is equal to the mean Diſtance from the Focus.

M. I conceive it. The ſmall triangular Area deſcribed in the Ellipſis, while the Velocity is equal to the Velocity in a Circle at that Diſtance, bears ſuch Proportion to the whole *Elliptical Area*, as the ſmall triangular Area, deſcribed in a Circle in the ſame Time, bears to the whole *circular Area*: And ſince theſe *like Parts* are deſcribed in equal Times, the whole Areas on each Side muſt be deſcribed in equal Times.

P. Therefore the periodical Times of a Body revolving in Ellipſis, and in a Circle at the middle Diſtance, that is, on half the greater Axis as a Radius, muſt be equal, or the ſame?

M. I ſee with much Pleaſure it muſt be ſo. ——

P. Laſtly, from all this you will now obſerve, that when the Projection is made with a Velocity greater than 1, and leſs than 1, 4142, *&c.* it is as neceſſary that the

the Body ſhould revolve about the Sun in ſuch an elliptical Orbit, lying unequally to oppoſite Sides of the Sun; as that it ſhould revolve about him in a circular Orbit, when the Velocity is as 1, and the Direction of the projectile Force at right Angles to the Direction of the attractive Force?

M. I ſee plainly the one Caſe is juſt as natural as the other, and follows as neceſſarily from the different Force, or Direction, in the firſt Projection. All that is thought unnatural in this Caſe diſappears, when the Conſequences of theſe different Conditions are rightly attended to.

P. This is all then you wanted to know; and I ſuppoſe by this Time you will allow, that we have ſpent more Time and Words upon it, than the Matter was worth; as I told you from the Beginning it would be.

CXLVI. *M.* Pardon me, *Philon*, I cannot allow any ſuch thing. We have not yet diſcourſed an Hour upon the Subject, and now I ſee the Reaſons of what before I thought an inexplicable Myſtery; beſides many entertaining Speculations which you have acquainted me with by the way. I have not thought the Time long. Or would you have had me,

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me, for the ſake of not converſing an Hour with you, to remain ignorant of thoſe things, perhaps for all my Life. If ever I come to apply more cloſely to ſuch Matters, I hope I ſhall conceive them more readily, for having ſeen the natural Reaſons of Things before hand: But if ſome unforeſeen Accident ſhould hinder my applying to them hereafter (which I hope and wiſh may not happen) I ſhall not at leaſt, from an Hour thus ſpent, be quite ignorant of them. And why do you make ſuch Haſte? This is the laſt time I am to give you any Trouble.

P. I know of little more that can be ſaid. You will eaſily collect by yourſelf, that there is no End of the Variety of Ellipſes, which may be deſcribed according to this Law of Attraction, more than of thoſe on the former Suppoſition: And there is a prodigious Difference alſo in the Degrees of their Eccentricity.

M. I ſaw before, that at whatever Diſtance we imagine a circular Orbit about the Sun, a Body might be ſo projected from any Point of it quite round, as to deſcribe an Ellipſis, which ſhould ſtill riſe to the oppoſite Side, and whoſe Plane ſhould be the

ſame

ſame with that of the circular Orbit; and that this Variety might be multiplied, as we ſuppoſed the circular Orbits to lie in different Planes: But I do not yet fully conceive what you mean by different Degrees of Eccentricity. Tenth Conference.

P. The Eccentricity, you know, is the Diſtance of either *Focus* from the Center; and you will eaſily conceive that the *Foci* may be ſtill more and more diſtant from the Center, either when the middle Diſtance is enlarged, and the Ellipſis becomes greater, or when the middle Diſtance remains the ſame, and the Ellipſis is of the ſame Length, but varies in Breadth. In the firſt of theſe Suppoſitions there muſt be an inconceivable Variety, as we have already ſeen: For if the Velocity as 1,4142 would carry off the Body to an infinite Diſtance, by any leſs Velocity than that, the Orbit muſt return upon itſelf, and incloſe Space, or make a bounded Figure. Hence the Velocity next leſs than that which would throw the Body quite off, muſt bring it back from an immenſe Height. This you yourſelf expreſſed very ſignificantly before, when you ſaid, *There was hardly any fixing a Limit between a boundleſs Space, and the next inferior bounded*

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bounded Figure. And accordingly, ſome Bodies, which thus revolve about the Sun, are ſuppoſed to take not many fewer than ſix hundred Years to perform their Circuit.

M. This is aſtoniſhing! Such a Body muſt riſe to an incredible Height, and have made but few Viſits down to the Center of the Syſtem ſince the World began!

P. Between this greateſt Height, and the leaſt (the *lower Vertex* of the ſame Ellipſis, for Inſtance) where a Planet might revolve about the Sun in not many Days, there muſt be a vaſt Difference, and Room for many intermediate Orbits.

M. What muſt become of ſuch a Body, if it ſhould fly off?

P. Who can anſwer ſuch a Queſtion as this, *Matho?* It could not fly quite off by Chance, nor be without Deſign, if it did: But it is needleſs to ſpend Time in Things we know ſo little about.——

M. Pleaſe then to tell me what you mean by the other ſort of Eccentricity, where the middle Diſtance remains the ſame?

P. It ſerves rather to acquaint you with the periodical Times of Bodies revolving in thoſe eccentrick Orbits, than that it really obtains in Nature.

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M. It would give me the greater Pleaſure to know a little about it on that very Account; though you have told me ſomething already concerning their periodical Times. It is often neceſſary, I find, to ſuppoſe Conditions which do not obtain, that we may the more readily conceive what is real: Thus your ſhewing me on what Conditions a Body might deſcribe an elliptick Orbit, about another in the *Center* of the Ellipſis, made me more eaſily underſtand how it might deſcribe an Ellipſis about another in the *Focus*. And without that Help, I don't know whether you could have beat it into my Head.

P. Since the Ellipſis is deſcribed about two Points, as the Circle is about one; the *greater Axis* remaining the ſame, you may conceive theſe two Points (or the two *Foci*) to recede from each other, nearer the Extremities of *this Axis*, till they co-incide with theſe Extremities, and the Ellipſis becomes a *ſtraight Line* on the one Hand; or to draw nearer one another, 'till they both co-incide with the Center, and the Ellipſis becomes a Circle on the other.

M. This I conceive without any Difficulty; becauſe, as I told you, we have tried

to

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to draw the Figure all manner of ways; but how does it ſhew the periodical Times of Bodies revolving in ſuch eccentrical Orbits?

CXLVII. *P.* You ſaw before that the periodical Time of a Body revolving in an Ellipſis, and in a Circle on the greater Semi-Axis, or middle Diſtance, as a Radius, is the ſame. Since therefore the middle Diſtance remains here unchanged, becauſe the greater Axis is ſtill the ſame, the periodical Times in *the Circle*, or extreme Ellipſis on the one Side, in all the *intermediate Ellipſes*, and in the perpendicular Aſcent and Deſcent through the *ſtraight Line*, which is the extreme Ellipſis on the other Side, will ſtill be equal among themſelves.

M. This is curious and entertaining. And I ſee the Reaſons we concluded from before, are ſtill applicable, let the Ellipſis become as narrow as we can imagine it, till it at laſt really become a *ſtraight Line*.

P. Now ſince the Squares of the Times are as the Cubes of the Diſtances, when the Bodies revolve in Circles; and ſince the Times in *Ellipſes*, and in *Circles* on their greater Semi-Axes as Radii, are equal; the

Squares of the periodical Times will be as the Cubes of the middle Diſtances, as much when the Bodies revolve in Ellipſes, as when they revolve in Circles, in which the middle Diſtance only remains, and the Eccentricity diſappears. Tenth Conference.

M. This Regularity and Agreement is wonderfully remarkable: But what I moſt admire is the Times of the perpendicular Aſcent and Deſcent. In the laſt Caſe, the perpendicular Projections, to what Height ſoever they roſe, were ſtill gone through in the ſame Time; becauſe the Revolutions in all Circles, how unequal ſoever, were ſtill performed in the ſame Time. And here the Times of perpendicular Projections obſerve the ſame Proportion with reſpect to their Heights, as the Times in circular Revolutions do with reſpect to their Diſtances.

P. You lay Things ſo well together in your Reflections, *Matho*, that you often help both yourſelf and me to right Views of them. It is certain, Harmony and Proportion run through all the Works and Laws of Nature.——

M. If therefore two Bodies were thrown perpendicularly up from the Sun, the ſecond 4 times higher, for Inſtance, than the firſt;

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the Time of its riſing and falling back, would be to the Time of the Aſcent and Deſcent of the other, as 8 to 1, that the Square of the Time 8 might be as the Cube of its Diſtance 4?

P. You are perfectly right.

M. By this Method, I preſume, we might find out in what Time the Planets would fall from their preſent Heights, down to the Center of the Syſtem, if their Motions were ſtopt; of which I remember you ſpoke before.

P. Very eaſily. The Time any Planet would take to fall down to the Sun, if its projectile Force ceaſed, would be half the Time it would take to revolve at half its preſent Diſtance: Or the Time of both its riſing and falling would be equal to a whole Revolution in a Circle at half the preſent Diſtance.

M. Give me Time to think of this; for I ſhould have imagined, inſtead of falling in half the Time of a Revolution at half the preſent Diſtance, it muſt have taken a 4th Part of the Time in which it performs a Revolution at preſent, at the whole Diſtance.

P. Conſider

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P. Conſider then which of the two it muſt be. ——

M. If the Planet revolved at half the Diſtance, and if the *Foci* receded from the Center to the Extremities of the Axis, the Ellipſis would become *extreme*, or degenerate into a ſtraight Line; and the Times both of revolving in the Ellipſis, and of riſing and falling through the ſtraight Line would be equal; for the middle Diſtance, or greater Semi-Axis remains the ſame: Their Halves therefore, or the Time of the perpendicular Deſcent in the ſtraight Line, and revolving in the Semi-Ellipſis, or Semi-Circle, at the middle Diſtance, would be the ſame. — I ſee it muſt be ſo. — To ſuppoſe the Time of the perpendicular Deſcent to be the ſame as the 4th Part of the Time of a Revolution in a Circle at the whole Diſtance, is to ſuppoſe that the Ellipſis degenerates into a ſtraight Line, and yet that the *Foci* ſtill keep together in the Center, which is inconſiſtent: Or it is to ſuppoſe the Ellipſis, when contracted into a ſtraight Line, to have the Sun, not in the *under Focus*, or extremity of the Line, but in the Center, or Middle of it.

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P. You correct your Miſtake very ingeniouſly.

M. More depends, I perceive, on your Way of conceiving the Eccentricity to become *extreme*, than I was at firſt aware of.

P. You ſaw from your own Deſcription of the Figure, that the only Way to make it narrower was by widening the Diſtance between the two Pins, or *Foci*, 'till they could get no farther aſunder for the Length of the Cord or String.

M. It was ſo. —— In order then to try this Calculation by myſelf, I firſt find out the periodical Time of the Planet at half the Diſtance, by the Proportion between the Squares of the Times and Cubes of the Diſtances; and Half of that will be the Time of its falling directly down to the Sun, from its preſent Diſtance?

P. Or the Whole of it will be the Time both of the Aſcent and Deſcent through that Height. —— Now, to conclude, *Matho*; from all this you will ſee, though the Earth and the reſt of the Planets revolve about the Sun in Orbits ſomewhat eccentrical, this no way diſturbs the Proportion between their periodical Times and the Cubes of their middle Diſtances. The Earth is farther from

from the Sun in the Summer, than in the Winter: For from the *vernal Equinox* to the *autumnal*, is about 8 Days longer, than from the *autumnal* to the *vernal*, becauſe the greater half of the Ellipſis is then to be run over; and about the Summer Solſtice the Sun's Diameter appears ſomewhat leſs, he being then farther Diſtant from us: And for all that we are not otherwiſe ſenſible of this, with Reſpect to Light or Heat: Our Heat particularly holds no Proportion with the Sun's Diſtance.

M. I am as glad now to know theſe Things, as I was before afraid, leſt they might have diſturbed what I already knew. From hence I perceive that it is manifeſtly a Work of Contrivance and Deſign, that the Planets ſhould revolve in Orbits ſo nearly circular. The Circle is but one of the innumerable Kinds of Ellipſes: And it is perfectly wonderful that ſo many Bodies ſhould be determined to this particular Species, when it was as natural and eaſy to revolve in any one of ten thouſand others.

CXLVIII. But you ſeem to inſinuate that there are different Bodies, which revolve

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about the Sun in thoſe eccentrical Orbits, and aſcend to a vaſt Diſtance from him.

P. Thoſe Bodies are indeed reckoned to be conſiderably more numerous than the Planets themſelves, either primary or ſecondary; and are now allowed to belong equally to our ſolar Syſtem. They revolve, you ſee, by the ſame Forces impreſſed, and obſerve the ſame Proportions in their Motions, as the Planets do. Some of their Periods ſeem already to be determined with a good Degree of Probability: But more of them are ſtill uncertain. This is a Subject for the Induſtry of future Ages. Thoſe *Comets* (for ſo they are called) do not move according to the Order of the Signs, or from *Weſt* to *Eaſt*, as the Planets do; but often directly contrary: Nor do they revolve in the ſame Plane with the Planets, nor in the ſame common Plane among themſelves; but move through the Syſtem all manner of ways: For this depends on their firſt Projection. Conſequently their *Aphelia*, or the remoteſt Part of their Orbits, lie indifferently to all Parts of the Heavens. They all riſe above the Orbit of *Saturn*; but ſome of them mount to a prodigious Height between that and the fixed Stars. Thus *that Comet*, whoſe periodical

riodical Time is reckoned to be 575 Years, riſes to about 14 times the Diſtance of *Saturn* from the Sun; which is an amazing Height, if we conſider it in itſelf, and not as it is expreſſed in this ſmall Number. Tenth Conference.

M. How is this found out?

P. Having the periodical Time and Diſtance of *Saturn* (or of any of the Planets) and the periodical Time of this Body, by the Proportion we have ſo often mentioned, between the Squares of the Times and Cubes of the Diſtances, you may eaſily find out its middle Diſtance, or half the larger Axis of its Orbit.

M. I remember it: We thus find out the Diſtance proportional to any Time, or the Time proportional to any Diſtance.——. And this at laſt diſcovers to me the Meaning of the Particulars concerning which I aſked you in the Beginning of our laſt Conference. The *Upward* and *Downward* with reſpect to the Sun, I ſee, or his Attraction, reaches far above the Orb of *Saturn*; ſince it extends to a Diſtance 14 times wider than the whole Planetary Syſtem. O! were it allowed us to find out what paſſes there!

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P. Your Wiſh is prepoſterous at preſent. The Knowledge of ſome Things is as wiſely denied us, as the Knowledge of others is indulged to us.

M. Well.——It alſo now appears wiſely diſpoſed, that all the Planets ſhould move in, or nearly in the ſame Plane; ſince other Bodies were to roam through the Syſtem all manner of ways: For thus, I ſuppoſe, their interfering, or daſhing againſt each other is prevented.

P. It is certain, *Matho*, ſince *God* preſides over all Nature, that nothing can be ordered as it is, without a wiſe Deſign. The *diſmal Cataſtrophe* you mention is wiſely prevented and perhaps by this Means. To ſuppoſe that ſuch fatal Shocks in Nature may caſually happen, or that the Planets may be liable to Decays and Dilapidations, is not, in my Opinion, right Philoſophy; but looks as if we imagined Matter were governed by a *blind Power*.

M. I come entirely into your Sentiments on this Head: But pray what is the Uſe and Deſign of thoſe wonderful Bodies, which move thus through the Syſtem, in a Manner peculiar to themſelves? Are they habitable? Why approach they ſo near the Sun? and

then

then run out to ſuch an unmeaſurable Diſtance from him? Can there be ſuch Bodies in other Syſtems? Or is ours ſingular?

P. You touch upon another ſignal Inſtance, where we ought humbly to adore and reverence a Knowledge ſuperior to our own, even in thoſe Things, the Uſe of which we are quite ignorant of.

M. And for all that I have heard *Comets* ſpoke of in Converſation, with a certain Dread and Horror.

P. That is the Thing: They rarely viſit us, or rather the groſs of Mankind rarely obſerve them; therefore their Appearance has been thought ominous. Formerly they were imagined to forebode ſome great Diſaſter, or general Calamity to the Inhabitants of the Earth: And lately they have been thought to be deſigned for bringing about great and fatal Changes to the Earth itſelf, by Deluges and Conflagrations. And certainly, when beheld through the Teleſcope, they make a frightful Appearance, with long blazing Tails, and ſomething like fiery Hair about the *Nucleus*, or Star itſelf. Others think they ſerve to recruit the Expenſe of the Sun and Planets, which without ſuch Reparations muſt waſte and become at laſt uſe-

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leſs. Others think this Expedient forced and unnatural, that a greater Number of Bodies ſhould only ſerve to repair the Decays of a ſmaller. And in Truth, all theſe Conjectures ſhew rather *that natural Impatience*, which is planted in the Mind of Man, of being ignorant, than their Ability, to find out the true Reaſons of Things.

M. How various and wonderful are the Works of God! This is a new and tremendous Scene! It is not indeed without Reaſon that you ſay, we ought to adore and reverence a Knowledge ſuperior to our own, even in thoſe Things whoſe Uſe and Nature we cannot ſo much as gueſs at. How dreadful is the Power of that *Almighty Arm*, which ſo projects theſe unknown Bodies that they paſs without the Limits of our World;— with ſuch meaſured Force, that they return from thence, inſtead of flying off to other Regions of the Univerſe;—— with ſuch Direction and Skill, that they do not daſh againſt the Planets, and bear down the habitable Globes of our Syſtem! How far are we from the full Knowledge of Things! Or can our Deſires of Knowledge ever be ſatisfied? Why are they ſo ſtrong and natural, if the ſatisfying of them be impoſſible?—

You

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You ſay *they are prepoſterous at preſent:* When will they be proper? —— after we are dead? You own *there is a natural Impatience planted in the Soul of Man.*

P. The Sentiments of Reverence, *Matho*, which the Subject we ſpeak of excites in you, ſeem to me juſt, and becoming; tho' your Expoſtulations are ſomewhat warm. But are you not afraid leſt they expoſe you to the Raillery of your *Equals?*

M. Why ſhould they expoſe me?

P. Thoſe, whom Birth and Fortune have raiſed above the inferior Crowd, laugh at theſe Things.

M. What is it then they are ſerious about?

P. Hounds, Horſes, Dreſs, Diverſions; and in Time, *Drinking, Gaming*, &c. &c.

M. I find I have no Turn for theſe great Exploits, and muſt be content with a leſs Share of Reputation than they afford. —— But with Reſpect to the Subject we are ſpeaking of, could you bear the Importunity of two or three Queſtions, for my Satisfaction, before I take my Leave of you?

P. Much more eaſily, I am afraid, than I could anſwer them.

CXLIX. *M.* In

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CXLIX. *M.* In the firſt Place then, as preparatory to what I want to know, tell me wherein a material Syſtem aids and aſſiſts the Soul to *know* and *underſtand?*

P. Inſtead of two or three Queſtions, you ſeem to begin a new and laborious Subject, which we have not now Time to diſcourſe upon at due Length.

M. Do not fear; I ſhall bring my Queſtions within a narrow Compaſs.

P. You have Principles whereby you may ſatisfy yourſelf in this Affair, if you call to Mind what we ſaid before, concerning the ſluggiſh and inactive Nature of Matter. A material Syſtem is made conſiſtent with a Degree of Life and Activity, by a wonderful Inſtance of Divine Power; but can no Way beſtow Life or Activity, or any Degree of them, upon the Soul. When we examined Matter in all Views, we found it utterly incapable of ever becoming a ſelf-moving Subſtance, even by *any Power*. To aſk if the Deity could make it *ſuch*, was to aſk if he could perform a Contradiction. Such a Thing is not the Object of any Power. It is joining together inconſiſtent Ideas in the Brain of Man; or rather joining together Words

Words in his Language, which expreſs inconſiſtent Ideas: Such Ideas cannot be joined. Hence Matter is a *reſiſting impeding Subſtance*, as it is a ſolid extended Subſtance. Conſider how deep theſe Things go. —— We know not, nor can we name a greater Abſurdity, than that *Union* to a dead and torpid Subſtance ſhould give the Soul Life and Power, or any Degree of them; or that *Separation* ſhould again deprive it of theſe. The Soul therefore muſt be percipient and active in its own Nature, independent of Matter —— Examine in your own Mind, if this be ſaying any more, than that *a living Being cannot owe its Life to Inertia and Deadneſs.*

M. It is ſatisfactory enough.

P. Farther, *Matho*; Matter, when beſt diſpoſed, muſt limit the Power and Activity of the Soul: And when diſordered or indiſpoſed, may quite obſtruct or impede its Operations; but can in no Manner *aid*, or *aſſiſt* its Power and Energy, otherwiſe than by *confining*, and *determining* them to one Manner of Exertion. Hence the Soul, when ſeparated from Matter, muſt be freed from Indiſpoſition, and have the Confinement taken off from its natural Activity.

M. That

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M. That is delightful!

P. And certain alſo; ſince the *Soul* is a living Being, and the *material Frame* a dead Subſtance, liable to Diſorder. Such a Frame, at beſt, can do no more than be inſtrumental in a limited Degree; and when the Parts of it are diſordered, the living Being languiſhes ſtill under greater Confinement. From hence proceed thoſe many equivocal Appearances, which we underſtand ſo ill, and reaſon ſo falſely upon. The Soul ſuffers from the Union, and has the Diſorders of the Frame imputed to it; while Matter is exalted above itſelf, in being made inſtrumental to the Activity of the Soul. Upon this Account we aſcribe the Life of the Soul to nothing ſo much as to Matter, or rather to nothing but Matter; and every Shock of the material Syſtem alarms us. They who ſeek a Name from Paradox and Novelty, take the Advantage of our ignorant Conceſſions, fortify our Fears, inſtead of unravelling the Subject, and triumph in the univerſal Loſs of Being, which they threaten to Mankind. Whereas, would we diſtinguiſh carefully in our Reaſonings, between two ſuch oppoſite Natures, it would be eaſy to diſappoint

point them. For, as I ſaid, the great Inſtance of Almighty Power is, that the Soul lives and perceives in Conjunction with Matter, and not that it ſhould live, perceive and act, when ſeparated from *that*. What we ſee ſhould remove our doubt; the great Difficulty is already performed: Every Act and Perception of the Soul, in a State of Union, is a firm and certain Proof, though but a faint Specimen, of the active and percipient Nature of the Soul, when exiſting by itſelf, and freed from the Limitation of a dead Subſtance. In ſhort, conſider Matter as it is in all the Univerſe beſide, as it is in a Stone, as it is in the Herb of the Field; the ſame it is in the Body of Man, the wonderful Workmanſhip only excepted.

M. You have ſaid enough, *Philon*: I call to Mind all the Particulars you ſhewed me at large before, concerning the inert Nature of Matter. Its very Sluggiſhneſs and Paſſivity ſuppoſes the Power of the Deity conſtantly exerted in every Effect it is thought to perform. So little can it impart Life and Activity to any other Thing! I am much pleaſed in this reſpect, that we conſidered the Nature of Matter ſo narrowly, and on all Sides.

My

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My Conviction was then, and is ſtill without any remaining Scruple. And now I ſee, that every Concluſion we then made was an Argument for the ſelf-ſufficient Nature of the Soul; in Oppoſition, I mean, to its ſubſiſting by the Help of Matter, or owing any Perfection to, or borrowing Power from that dead Subſtance. —— One Thing more with Reſpect to this, which you may anſwer in two Words, and I have done. What do you mean by thoſe *who ſeek a Name from Paradox and Novelty?*

P. In two Words, the Mortality of the Soul is but an upſtart Notion, when compared with the Knowledge of its immortal and unperiſhing Nature, which is as ancient in the World, as the Creation of the very firſt Man: Nor was it called in Queſtion for a long Series of Ages (I might tell you near the very Olympiad), when Men began to affect a new Reputation of Learning, from maintaining what was never heard of before. Then at length the Exiſtence of the Deity and Immortality of the Soul began to be diſputed.

M. You mean that theſe two Truths were immediately revealed by the Creator himſelf to the firſt Man?

P. I do;

P. I do; and this is as certain as any Truth in Philoſophy.

M. I remember ſomething you curſorily hinted concerning the Creation, in our paſt Diſcourſe. —— But might not theſe Notions have been again forgot, or fallen into Oblivion?

P. They never could be forgot by ſuch a dependent Creature as Man. They might in Length of Time be diſguiſed by idle Fables, or human Inventions ſuperadded, (as indeed happened), but it is impoſſible they could ever wear into Diſuſe, or be loſt; there are ſo frequent and ſo many Occaſions to call them to mind, in Life, and in Death. The Indefeaſibleneſs of theſe two Principles is owned, or rather clearly proved, by ſome Authors, who notwithſtanding contend that there are whole Nations of original Atheiſts, without any Notion of, or Name for *a Supreme Being:* So that you may eaſily allow, it cannot be denied.

M. I begin to ſee the Reaſons why ſuch Notions, once broached in the World, muſt be conveyed down to all Poſterity. But then if it be certain that they were revealed to the firſt Man, it is hard to conceive that

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there ſhould be any where a Nation of Atheiſts: For all Men muſt have deſcended from him, and theſe Notions have been propagated together with the Species.

P. You have Reaſon ſo to ſay. Atheiſm and Irreligion is not the Vice of Ignorance, but of miſapplied Knowledge. * And that there ſhould be whole Nations of original Atheiſts is contrary to the Reaſon and Nature of Things; unleſs we will ſuppoſe that Men at firſt grew out of the Ground, in different Parts of the Earth, ſome upon the Banks of the *Tanais*, and others among the Flags of the *Nile*.

M. You bring to my Mind the old Diſpute between the *Scythians* and *Ægyptians*. — Theſe ſhort Hints you have now ſuggeſted, I muſt conſider by myſelf hereafter; but to come to the Particulars I principally intended, tell me

CL. Is it poſſible that a Man might not be delighted with the Knowledge and Contemplation of the Works of Nature, which we have been diſcourſing about?

* See *Ælian*'s various Hiſtory, Book II. Chap. 31. Οἱ μηδεὶς τῶν Βαρβάρων ἄθεοι.

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P. It is directly impoſſible that a rational Being could be indifferent, or unconcerned about them. We are carried by Reaſon itſelf, the commanding Part of our Nature, to the Admiration and Study of thoſe Works. A natural Curioſity, no Footſteps of which is to be ſeen among the inferior Creatures, at firſt engages us, (ſo artfully are they contrived to catch the Soul with Wonder!) and this is ſoon improved into a rational Pleaſure. And ſince they are the Works of the Deity, by how much the more we ſee the Power and Wiſdom diſplayed in them, ſo much the more muſt we admire and reverence their Author. But farther, they were ſet forth purely with this very Deſign; for you ſaw before, *That all Things were made for the Sake of rational Beings.*

M. It is inconteſtable that what is of leſs Dignity, muſt always be referred to the Uſe of that which is more noble; and Reaſon is the higheſt Perfection among Creatures.

P. He therefore, who has not a Taſte for this rational Pleaſure, muſt have his Mind pre-occupied, and engaged in lower Purſuits.

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M. And he, who follows the Dictates of Reaſon, muſt always wiſh for a more perfect Knowledge of the Works of Nature?

P. Certainly: Inſomuch that he cannot diſengage himſelf from this Deſire, otherwiſe than by firſt enſlaving his Reaſon, and making it ſubſervient to inferior Views.

M. Will this endleſs Deſire of Knowledge be always ſatisfied?

P. Put the Queſtion thus, *Matho; Will God, who is the ſupreme Reaſon, ultimately gratify the rational Deſires of his Creatures?* and then try if you can doubt of it.

M. Hence then the Soul muſt not only be immortal, but endleſſly happy?

P. And endleſſly advancing in Happineſs alſo; ſtill going forward in the Improvement of its Nature, and the Knowledge of the Perfections of its Creator. Whence (if I might uſe the Expreſſion) the Relation between the Deity and the rational Soul ſtill becomes ſtronger. For it is altogether contrary to the *Eternal Reaſon* (which Truth you ought to have ſtrongly imprinted on your Mind, as a Cure againſt the Fear of Death, and a Comfort in the Miſeries of Life;) it is, I ſay, altogether

contrary

contrary to the *Eternal Reaſon*, that by how much the more perfect the rational Soul becomes, it ſhould be ſo much the nearer to becoming nothing. Which Abſurdity muſt nevertheleſs take Place, if it were ever to have an End. Hence the longer it lives, the leſs it can die.

M. O! pleaſing Truth! Happy Condition of the rational Nature!

P. Suppoſe, *Matho*, for a ſkilful Artiſt does nothing raſhly, deſigns nothing in vain; ſuppoſe that the Deity, through all the Lapſe of paſt Ages, has ſupported the Univerſe by ſuch Miracles of Power and Wiſdom, only that he might at laſt pleaſe himſelf, with letting it fall to Pieces, and enjoy the Spectacle of the Fabrick lying in Ruins.

M. Can I harbour ſuch a Thought of the Deity! Or ſuppoſe this a Deſign worthy of infinite Wiſdom!

P. Suppoſe at leaſt, that the Deity will utterly cut off *that Nature*, for whoſe Sake he created the Univerſe; the material Fabrick itſelf ſtill remaining.

M. This is ſtill more againſt the Nature of that Being, who is the *Eternal Reaſon* to aboliſh the rational Part of his Works, and cheriſh a Heap of Matter!

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P. Can there then be a greater or ſtronger Security for the Immortality of the Soul, than the *immutable* Nature of the Deity?

M. I ſee, *Philon*; I ſee the happy Condition of the rational Nature! Eternal Reaſon that cannot yield to Time or Accident, to Sickneſs or Death, and the *Divine Nature* that cannot change, are the firm Pledges of its Immortality! You have made me as ſecure, as if I were already among the *Bleſſed*, and in the Poſſeſſion of Joys beyond the Grave. This is the only *Amulet* againſt the Fears of Death, and Evils of Life. The Nature of the Soul, and the Deſign of the Deity in creating it ſuch now appears.

CLI. *P.* Let thoſe Men conſider this, *Matho*, who are ſuch zealous Partiſans for the Mortality of the Soul.

M. It ſurpriſes me much that any Man ſhould ſhew his Zeal in defending ſuch a Notion, or be ſo much an Enemy to himſelf as ſeriouſly to wiſh it true.

P. You may ſoon meet with ſuch Books where the Notion is defended.

M. I ſhould hardly think them worth the Peruſal; for it ſeems to me a direct Contradiction

tradiction that any Man ſhould be in love with *being Nothing*, becauſe then he could have no Deſire remaining for any Thing elſe. It is, I think, in Conſequence of our Love of Exiſtence, that we deſire any other Thing whatever, that we wiſh one Thing rather than another, and conſult our Reputation even after Death. Why ſhould a Man who wiſhes to be nothing care for what might happen, or for what might not happen, hereafter? Or even before? He can have no Intereſt in any Events, provided he be cancelled out of Nature. The only conſiſtent Action he could go about, were immediately to put an End to his Life, and do all in his Power to get rid of *Being*. In ſhort, as Things appear to me, the Deſire of Exiſtence is the Foundation of all our other Deſires, and of all our *Endeavours*: Otherwiſe let me ſee what it is a Man ſhould wiſh or ſtruggle for, who wiſhes to have no Relation with Beings, or their Actions; or any Thing in Exiſtence? To wiſh that the Relation with Things exiſtent ſhould continue, and to loſe Exiſtence at the ſame Time, is repugnant.

P. You ſhew extremely well, *Matho*, not only the ſhameful Falſhood that lurks

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in the Soul of a Man, who ſhews a Zeal in propagating this Notion; but the expreſs Contradiction that a Man ſhould be concerned for any Thing, whoſe greateſt Concern it is that he himſelf ſhould be nothing. The greateſt Concern, I ſay; for if any other Concern could be greater, that muſt be for Things in Exiſtence: Non-exiſtence has no Concern belonging to it. And if he had a greater Concern about Things in Exiſtence, he muſt, by the Exceſs of his two Deſires, wiſh to exiſt himſelf, that he might contribute his Endeavours, or participate the Pleaſure of the Succeſs. You remember the laſt deſperate Comfort of the *Carthaginian* Queen; *Omnibus umbra locis adero*; —— No Man ever wiſhed to be totally extinguiſhed in Death, who had any Concern about poſthumous Events.

M. I remember likewiſe the Story, how the Shame of being expoſed naked after Death hindered the *Mileſian* Virgins, I think, from putting an End to their Lives, when nothing elſe could. Nor can I conceive how any Perſon could throw aſide all Concern for his poſthumous Reputation. Which ſhews, not only that he does not wiſh, but that he does not ſuppoſe he

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ſhall be quite extinguiſhed in Death. And though it ſhould be ſaid, that this is but a groundleſs Prejudice which Men fall into, yet it ſhews that the Deſire of being always *Something*, and the Preſumption that we ſhall always be *Something*, is ſo much the ſtronger.

P. The Diſingenuity of theſe Men's Zeal appears alſo from thence, *Matho*, that Non-exiſtence is really nothing, and ſo cannot in the Nature of Things be the Object of Deſire: All the Objects of Deſire lie clearly on the other Side. It may be ſaid, it can as little be the Object of Averſion; but the Good it would deprive us of makes it as much the Object of Averſion, as *a real Evil* can be.

M. The Conſequence is plain.

P. Since therefore we can only deſire *Something real*, that is, Exiſtence and Pleaſure; ſince this is the Law of our Nature, and equal to a phyſical Neceſſity; we cannot be ſo conſtituted by the Author of our Nature, as neceſſarily to deſire one Thing, and be deſigned for another, which is the direct contrary of it. Had we no Deſires at all, or rather were we cloyed with Exiſtence and diſguſted with Happineſs, that would

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would ſhew that we were deſigned for utter Extinction: But it is repugnant that Happineſs ſhould be diſguſting, or other than the Object of Deſire.

M. From what you ſay it ſeems to follow (and I ſee it muſt), that Miſery and Pain are the only Objects of Averſion in the Nature of Things.

P. You are very right: And from this again it will likewiſe follow, that they only, who fear the bad Conſequences of a mis-ſpent Life, can wiſh for a total Death. And this, when you have examined Things on all Sides, you will find to be the only Caſe wherein it is poſſible to wiſh to be utterly cut off: But it is in vain; the Law of our Nature is as immutable as Fate. Puniſhment is as unavoidable in the one Caſe, as Happineſs is certain in the other. ——This likewiſe is poſſible (ſo perverſe is Man!) that ſome may ſtrongly contend for the Mortality of the Soul, out of Vain-Glory; though at the ſame Time their Nature ſhrinks back at the ſerious Thoughts of it. And though ſome ſhould puſh this Affectation ſo far as to make it a Point of Honour, to appear conſtant to the laſt, for Fear of bringing a Diſrepute upon their Character,

Character, or their Principle (as is reported of the famous Atheiſt *Spinoza*;) yet this ſhews the Inconſiſtency of their Thoughts, or rather the Perverſeneſs and Diſingenuity of their Hearts, to pretend a Concern for their Reputation, and a Fondneſs of being nothing at the ſame Time. So that there is nothing but Perverſeneſs and Contradiction on this whole Side of the Queſtion. Tenth Conference.

M. Thoſe Men, I think, affect the Reputation of *Parricides*, or of a Crime for which Language has not a Name; who place their Zeal in ſhewing that the rational Soul muſt be cut off, and that there is not a Deity to govern the World. If this were Matter of Triumph to them, what is it that could be Matter of Grief and Dejection!

CLII. *P.* On the other Hand, *Matho*, we might obſerve that, as it draws near to the brute and unthinking Nature, not to deſire the Continuation of Exiſtence, ſo the greateſt, the beſt and moſt virtuous among Men have ſhewn the moſt ardent Deſire for the Immortality of the Soul. This is the Spring of all the virtuous Actions in Life. No Man ever died in the Cauſe of Virtue and Liberty, for the Sake of Truth, in Defence

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fence of his Country, or on the Account of Poſterity; who had not Immortality in ſome Senſe or other before his Eyes. *Cicero* ſays, *Nemo unquam ſine magna ſpe immortalitatis ſe pro patria offerret ad mortem.* He obſerves that *Themiſtocles*, *Epaminondas*, all the great Men of Antiquity, and he himſelf, needed have given themſelves no Trouble for the Sake of the Commonwealth; but adds, —— *Sed neſcio quomodo inhæret in mentibus quaſi ſæculorum quoddam augurium futurorum; idque in maximis ingeniis, altiſſimiſque animis, & exiſtit maximè, & apparet facillimè: Quo quidem dempto, quis tam eſſet amens, qui ſemper in laboribus, & periculis viveret?* Why do we ſo ſtudiouſly provide for our Children, but becauſe we think the Relation between us and them is to laſt after Death, interminately? No Man fixes a Period to his Views in this Caſe. We endeavour by great and noble Actions to deſerve well of our Country; not becauſe we wiſh ſoon to be cut off from the Nature of Things; that would be the Source of *Indifference*, of *Neglect*, of *Selfiſhneſs*; but becauſe we preſume we ſhall ſome Way or other ſtill have an Intereſt in the Welfare and Proſperity of the Survivors. It is

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from this ſecret Spring that the Legiſlator invents and digeſts ſuch a Syſtem of Laws, as he thinks may be eternal. He adopts the whole Common-wealth for his Offſpring, and upon that Account never propoſes an End of the Relation between him and them, more than a Parent does with Reſpect to his Children. He provides as far as human Foreſight can, a Remedy againſt every Emergence or Accident which he fears might prove fatal to the Community; and figures to himſelf, in the ſecret Workings of his Mind, their thriving and flouriſhing in Ages to come, without any Bounds to the pleaſing Proſpect *. —— I need not purſue this Subject farther for you, *Matho*, your own future Obſervation will

* Theſe ſeveral Notions will be allowed to be more authentick, when it is known they are *Cicero*'s. His Words are, —— Maximum verò argumentum eſt, naturam ipſam de immortalitate animorum tacitam judicare, quòd omnibus curæ ſunt, & maximè quidem, quæ poſt mortem futura ſunt. Serit arbores, quæ alteri ſæculo proſint, —— quid ſpectans, niſi etiam poſtera ſæcula ad ſe pertinere? Ergo arbores ſeret diligens agricola, quarum aſpiciet baccam ipſe numquam. Vir magnus leges, inſtituta, rempublicam conſeret. Quid procreatio liberorum, quid propagatio nominis, quid adoptiones filiorum, quid teſtamentorum diligentia, quid ipſa ſepulchrorum monumenta, quid elogia ſignificant, niſi nos futura etiam cogitare. *Tuſcul. Quæſt.* Lib. 1.

ſhew you, that the Deſire of Immortality, in ſome Senſe or other, is the Source of every great, every brave, and gallant Action among Men. Read ancient Hiſtory, conſider the preſent Times, look into the Works of the Learned, fix your Eyes on all the greateſt Examples, on every the moſt conſpicuous Perſon; you will find all full of this Spirit, and ariſing from this Deſire.

M. What you ſay gives me a different Proſpect of Things from what I had before. I begin to ſee that the Deſire of Immortality in ſome Shape or other, or perhaps under ſome Diſguiſe, is the great *Principle* that animates human Life: Or rather I ought to have ſeen it before, when I ſaw that the Deſire of Exiſtence is the Foundation of all our other Deſires, and of all our Endeavours. Hence the *loweſt*, as well as the *greateſt*, among Men, are conſtantly puſhed on by this Principle; ſince all the Proviſion that is made for Life, is plainly an Endeavour for the Continuation of Exiſtence, and not with a View to put an End to *Being*.

P. The Obſervation is very juſt. The Principle of Self-Preſervation always works for the Continuation of Exiſtence, and in

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a *reflecting Being* formally extends to the Deſire of Immortality; which therefore cannot be found in the brute Nature. This Deſire may often degenerate into a Vice, as when we think we can never make Proviſion enough for the ſenſitive Part of our Nature: It is then under a Diſguiſe, but ſtill it is at the Bottom. The Deſire is ſtill good in itſelf, and neceſſary to our Nature: But Reaſon then is made the Slave of Senſe, and perhaps the Inſtrument of Vice. In ſhort, *Matho*, This *original Deſire* ſhoots out into a thouſand different Forms of Action: In the ordinary Efforts of Life it is leſs taken Notice of, becauſe every one purſues the ſame Track; but where it ſtrikes out of the common Road, it becomes remarkable. Conſider how many different Ways Men have taken to preſerve their Memory when gone. Every one who has *Power*, or *Money*, or *Genius*, falls on ſome Means or other, to inform Poſterity, that ſuch a Perſon once exiſted. —— *Et quatenus nobis denegatur diu vivere* (ſays *Pliny* the younger) *relinquamus aliquid, quo nos vixiſſe teſtemur.*

M. It is ſo; Men have contrived ſome Sort of a Way to ſurvive themſelves in Braſs and

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and Marble; in Books, Buildings, Monuments, Pyramids, Pictures, Pillars, Inſcriptions, and many more Ways than I can name. What would not Men give for Exiſtence itſelf, when they endeavour to preſerve the bare Memory of having exiſted with their utmoſt Induſtry! For it is certain that all Deſire of poſthumous Praiſe and Reputation proceeds from a Deſire of poſthumous Exiſtence, if I might uſe ſuch an Expreſſion.

P. And in this Reſpect, thoſe very Men who boaſt the Happineſs of being utterly cut off, ſhew themſelves equally induſtrious with others; whereby their Candor and Ingenuity may be judged of *. The Atheiſt is formed in Oppoſition to his own Principles: He burns with a Deſire of poſthu-

* Thus *Lucretius*,

Avia Pieridum peragro loca, nullius antè
Trita ſolo; juvat integros accedere fonteis;
Atque haurire: Juvatque novos decerpere flores,
Inſignémque meo capiti petere indè coronam,
Unde priùs nulli velârint tempora Muſæ.
Primùm quòd magnis doceo de rebus; & arctis
Relligionum animos nodis exſolvere pergo:
Deinde, quòd obſcurâ de re tam lucida pango
Carmina, Muſêo contingens cuncta lepôre.

Lib. 4. Ver. 1. The Author here builds his immortal Fame on the Doctrine of Annihilation!

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mous Praiſe, as well as preſent Admiration: He writes, diſputes, propagates his Principles: He cannot diveſt himſelf of the Deſire of Exiſtence: No Man ever got above that Deſire, except in the particular Caſe I mentioned to you. Therefore it is a fallacious Argument in a late famous Apologiſt for Atheiſm, to tell us how many great and learned Men have been Atheiſts *. Were it ſo, their Learning could be no Plea for their Principles; more than this Author's is for the Defence he makes for them: But in Truth Learning and Knowledge never made a Man an Atheiſt, nor never will.

* Mr. *Bayle*, when he would ſhew us how conſiderable Atheiſm is, ſays —— Que ſi, ſans repeter tous les examples que j'ai deja rapportez ou dans mes Penſées Diverſes, ou dans mon Dictionaire, je vous nomme ſeulment quelques-uns des modernes, que l'on accuſe d'Atheiſme, un Averroes, un Calderinus, un Politien, un Pomponace, un Pierre Bembus, un Leon Dixiéme, un Cardan, un Ceſalpin, un Taurellus, un Cremonin, un Berigard, un Viviani, un Thomas Hobbes; pourrez-vous croire avec le Pere Rapin qu'il n'y a qu'un petit Auteur de ſonnet ou de madrigal, qu'un Debauché, qu'un Courtiſan, & qu'on femme galante qui ſoient ſuſceptibles de l'irreligion? Peut-on caracteriſer ainſi les Philoſophes, les Medicines, les Mathematiciens, les Humaniſtes les plus celebres? *Continuat. Des Penſ. Diverſ.* §. 18. It could never recommend *Avarice*, or any Vice, to tell what Numbers had been addicted to it.

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It is an eaſy Thing to doubt, or deny; and it is Ignorance only of *Nature* can make a Man do either in this Caſe.

CLIII. *M.* From what we have ſaid it eaſily appears what the World would come to, without this enlivening Principle.

P. The Affairs of Men could not then long ſubſiſt. Had they a contrary Deſire, every one would inſtantly ruſh upon Death as the likelieſt Means to get out of *Being*: And there muſt be an End of the Species at once. Or, had they no contrary Deſire, but an Indifference whether they exiſted or not, whether they were *ſomething* or *nothing*, all the Endeavours in Life muſt inſtantly ſtagnate, and in a little Time utterly ceaſe. No Man would act without a Motive of Action, having nothing deſireable, nothing worth while, to put him upon exerting his Powers. If the Continuance of Exiſtence were not a Motive (as you ſaid before) nothing elſe in Nature could.

M. This affords us a compendious View of what we ſaw before only in Parts; namely, That this Deſire of Exiſtence is the only Spring of all the Induſtry in Life; and

and therefore not only of what we do for ourselves, but of the generous Actions we do for others. If we would do no Action without it, it must be the Source of the one Sort of Actions as much as the other.

P. You are right. We saw this Truth before, by Way of *Induction*, or an enumeration of Particulars: And now we see it by a contrary Sort of Argument. The Desire of Existence in a *Reflecting Being* is never bounded; but (as has been said) extends itself formally into the Desire of endless Existence. Man having this endless Desire, is susceptible of that Affection in his Nature which we call *Sympathy*, and which may be explained by *Fellow-feeling*, or *Compassion*. All Sympathy therefore supposes the *feeling* first in ourselves; or *Fellow-feeling* is founded upon *Self-feeling*.

M. I conceive it: Sympathy must be a Contradiction without this; as if it were said, we felt the endless Desire of Existence with another, which we do not feel with another.

P. From this Sympathy then (which is thus founded on the previous Desire, or Self-feeling) Man becomes social, friendly, and benevolent: He exercises Acts of mu-

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tual Forbearance, he defers the immediate Gratification of his Pleaſures, and undergoes Pain for the Sake of others: Becauſe in this large Proſpect, (and in this Proſpect only) he ſees there is Room for the rational Deſires of all Beings to have their full Conſequence, and for the Happineſs of all to be made conſiſtent.

M. I am in love with this Deduction; one Part of it falls in naturally with another, ſo that it ſeems firm and compact. And it is doubly agreeable to ſee, that this Deſire of endleſs Exiſtence, ſo ſtrong in the Nature of Man, is the Foundation of all ſocial Virtue; of all great, brave, and generous Actions. A Paſſion ſo predominant in our Nature muſt be good in its Conſequences.

P. After this therefore you will eaſily perceive, that thoſe Philoſophers, who lay the Foundation of Virtue in the ſocial and benevolent Nature of Man, or in the Beauty of Virtue, or the Harmony of virtuous Actions, independent of the Immortality of the Soul, and without any Regard to ourſelves, raiſe a Structure without a Baſis. If a Man be indifferent about being *Something* or *Nothing*, he would hardly exert thoſe Efforts out of Benevolence to others, which

which he would not exert for the Sake of his own *Being*: Or the Exiſtence of others could not be a Motive of Action to him, if his own Exiſtence were none. Tenth Conference.

M. This is very true: But their Structure ſeems chiefly without a Baſis in this Reſpect, that Man could have no Benevolence, or Sympathy, without a Self-feeling *. Thus they lay the Foundation of Virtue in the Benevolence of Man, but they leave this Benevolence without a Foundation: Therefore they leave Virtue without a Foundation.

P. Or we may conſider the Caſe thus, if Benevolence be our Duty, it is but our Duty in Conſequence of Exiſtence, and not in Conſequence of being Nothing. As Benevolence therefore ſuppoſes Exiſtence, it ſuppoſes our Endeavours for the Preſervation of our own Exiſtence, or a Love to ourſelves in the firſt Place; otherwiſe the Exerciſe of that Virtue, and indeed of all Virtue, becomes contradictory. So abſurd is it to make ſocial Virtue, or Virtue under a-

* We may obſerve here in paſſing, that the Goodneſs of God to his Creatures is of a purer Nature than the Benevolence of Man to Man; as the Divine Bounty cannot proceed from a Fellow-feeling, or Fellow-Suffering, but is perfectly free and gratuitous.

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ny Denomination, independent of Love to ourſelves, or of Deſire of Exiſtence!

M. That is the Notion I had; and it gives me the greater Satisfaction, as I find it ſo agreeable to my Nature.

P. No Man therefore could die for his Country, or for the Sake of Virtue, without a Deſire of Exiſtence, at the ſame Time that he parts with Life: From which let the Concluſion be drawn.

M. O pleaſing Concluſion! It is this; The Exerciſe of Virtue proceeds on the Suppoſition that Exiſtence is not confined to Life, or reaches beyond Death! From what you have ſaid, it is plain that the Exerciſe of Virtue, nay the Support of Society becomes otherwiſe contradictory. The rational Nature itſelf, and the Practice of Virtue, leads us ſilently by the Hand to this Truth, and lands us, lands the moſt illiterate virtuous Man, on a happy Immortality, without the Noiſe of Controverſy and Arguments. ——

P. It is ſaid by a great Author, *Matho*, That we ought to give up our very Being for the Sake of our Country. But firſt, Being is not a Thing ſo eaſily to be got quit of, though we ſhould be willing to part

part with it: Our Being is not at our Diſpoſal. And then, if we be indifferent about Exiſtence or Non-exiſtence, that is, if we have no Love for ourſelves, this can be no Virtue: We part with a Thing for which we have no Value. Where again we ſee that taking away Love to ourſelves takes away the Nature of Virtue. Beſides, if this be a Duty incumbent on any one Member of the Society, it is a Duty incumbent on every Member in it, to part with Being; and —— for the Sake of what? The Society conſiſts but of all its Members. It is abſurd to make that the Duty of *every one*, which would ruin the *Whole:* It is fooliſh to ſuppoſe that the Non-exiſtence of any Being might be made the Condition on which the Safety of the Society depended: And it is begging a material Queſtion to ſuppoſe that when a Man dies for his Country he becomes Nothing.

M. All this is obvious from what we have ſaid.

P. In fine then, as the Practice of every Virtue ſuppoſes Exiſtence, the Obligation to the Practice of every Virtue ſuppoſes, in the firſt Place, the Obligation to love and defend our own Exiſtence, to

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which you ſee we are ſo ſtrongly carried by our Nature. Hence the Beauty of Virtue, or Harmony of virtuous Actions, or any other Pretence that can be deviſed, could fix no Obligation upon us without this Foundation. The Notion *that Virtue is its own Reward* hath been long boaſted: But this conſtitutes no Obligation. If a Man is willing to part with the Reward, he will be under no Obligation to the Practice. The virtuous Man rather will be moſt *in* love with Exiſtence, or Immortality; becauſe it is of more Value to him than to another: He will likewiſe do moſt for the Sake of it, and therefore be moſt ſocial and benevolent, for the Reaſons I juſt now mentioned; becauſe, on this Suppoſition, he ſees there is Room for all rational Deſires to be gratified, and the Happineſs of all to be made conſiſtent; a Condition that cannot be met with again, if we exclude the Immortality of the Soul. And to call this a *ſelfiſh*, or *intereſted Scheme*, by Way of Contempt, and the contrary Suppoſition, which muſt have very different Effects, the *benevolent Scheme* is (to ſay no more) a changing the Names of Things.

M. Since the Author of our Nature has ſo conſtituted the Actions of rational Beings, that the Man who acts moſt for his own Intereſt acts moſt benevolently toward others at the ſame Time; the Attempt to make *Intereſt* and *Virtue* claſh, or to ſettle them on ſeparate Foundations, can never be juſtifiable.

CLIV. From all this I am ſatisfied, it muſt be a great Comfort to the Life of Man to conſider, that the Deſire of Immortality is the Source of all Virtue; that our Proſpect of a *Futurity* is our only rational Security at preſent. A Deſire which has ſuch ſalutary Conſequences cannot be implanted in our Nature in vain, nor remain unſatisfied. —— But pray tell me now, is it poſſible that a Nation of Men denying the Being of a God, and the Immortality of the Soul, could ſubſiſt together in a Society, upon their own Principles? This I the rather aſk, as the Thing ſeems to be ſuppoſed *Fact*; and yet, if we have reaſoned right, it muſt be impracticable.

P. This you may eaſily ſatisfy yourſelf about: For, if you remember, when we conſidered the neceſſary Exiſtence of a Deity, we

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we found that a Being of infinite Power, Knowledge, Goodneſs and Juſtice; or (to expreſs it in fewer Words) a Being of infinite Perfection, was neceſſary; ſince a Cauſe without Power and Knowledge (that is an ignorant and impotent Cauſe) could not have produced ſuch a Being.

M. I remember it diſtinctly; and therefore, that an infinitely perfect Being muſt either exiſt neceſſarily, on the one Side, or imply a Contradiction to exiſt, on the other; there is no Medium, ſince the Cauſe of ſuch a Being is ſo ſtrongly repugnant.

P. So we found it. —— The denying of ſuch a Being therefore is equal to affirming the Impoſſibility of Power and Perfection in any Degree?

M. It is: The ſame Argument repeated over again ſhews *abſolutely*, that if Power and Perfection be not neceſſary they muſt be impoſſible in any Degree; becauſe they could not ſtart up from nothing, or from their Contraries, which are only *mere Negations*. And then it ſhews that, if Power and Perfection be at all neceſſary, it muſt in an unlimited Degree: For, as Impotence and Imperfection could not produce Power and Perfection, no more could they limit theſe.

theſe. Impotence, as we ſaid, could do nothing againſt Power, nor Ignorance againſt Knowledge. Therefore it is plain, that denying a Being of infinite Perfection is affirming the abſolute Impoſſibility of Perfection in all Senſes.

P. The Atheiſt therefore abſolutely denies the Poſſibility of Power, Knowledge, Juſtice, Truth, Goodneſs, and every Perfection; ſince he does not leave a Difference in Nature between Perfection and Imperfection.

M. This is moſt unnatural and ſhocking! Yet the Conſequence is plain. He takes away the very Foundation of Perfection, and therefore cannot leave a Difference between it and the Negation of it; for all is the Negation of it.

P. He takes away, by this Means, the Difference in Nature between *Juſtice* and *Injuſtice*, *Right* and *Wrong*, *Virtue* and *Vice*, *Truth* and *Falſhood*?

M. He does indeed; becauſe Juſtice, Truth, Goodneſs, *&c.* cannot be the Affections of *ſurd Matter*, *Emptineſs*, *Chance*, *Impotence*, *Ignorance*, or any thing he leaves in Nature.

P. From

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P. From this then you may ſee, that a Nation of Men denying the Being of a God, and the Immortality of the Soul, could not ſubſiſt together in a Society on their own Principles; their fundamental Principle, being deſtructive of all other Principles, takes away the Difference between Right and Wrong, Juſt and Unjuſt; in a Word, tears up all the Laws of *Government* by the Roots. And though the groſs of Mankind do not go thus philoſophically to work, to ſhew that the Difference between Virtue and Vice is taken away by the Principles of the Atheiſt, yet (as all Men are ingenious enough to reaſon on the Side of their Inclinations, and the worſe their Inclinations, the more ingenious) they readily enough draw an equivalent Concluſion in Practice. "If there "be neither God nor Religion (ſay they) "nor a future State, we may do what we "liſt: If we can by Force or otherwiſe, "ſecure our ſelves from Men, who have "contrived theſe Notions, all is as well "with us as with others, nay better." Theſe are the parallel Arguments of every Ruffian, how ignorant ſoever. There is ſuch a ſtrong Relation in Nature between Juſtice and the Puniſhment of Vice, that Atheiſm

Atheiſm leads the moſt unlearned Mind to the Proſpect of Impunity.

M. This is terrible Work! But pray what ſays the Author, whom you called the Apologiſt for Atheiſm, to all this?

P. He makes no Difficulty to ſuppoſe, That Atheiſts might live together in Society, provided they had good Laws, and thoſe ſeverely put in Execution; which he obſerves, is neceſſary in all Societies, as well as among Atheiſts *.

M. On what Principles ſhould theſe Laws be founded?

P. He does not ſay.

* Mr. *Bayle* ſays (Penſées Diverſes §. 161.) "Après "toutes ces remarques je ne ferai pas difficulté de dire, "ſi l'on veut ſçavoir ma conjecture touchant une Societé "d'Athées, qu'il me ſemble qu' à l'égard de mœurs, & "des actions civiles, elle ſeroit toute ſemblable à une "Societé de Payens. Il y faudroit à la verité des Loix "fort ſeveres, & fort bien executées pour la punition "des criminels. Mais n'en faut-il pas par tout?"—— And again (§. 172.) "On voit à cette heure, combien "il eſt apparent qu'une Societé d'Athées prattiquerot les "actions civiles & morales, auſſi bien que les pratiquent "les autres ſocietez, pourvû qu'elle fît ſeverement "punir les crimes, & qu'elle attachât de l'honneur, & "de l'infamie à certaines choſes." Could Vice be branded with greater Infamy than at preſent, when the national Principle denied the Difference between Virtue and Vice?

M. They

M. They could not be founded on the Atheiſt's own Principles; for thoſe take away the Difference between *Right* and *Wrong*, and tear up (as you ſaid juſt now) all the Laws of Government by the Roots.

P. Certainly they could not.

M. That is to ſay then, Atheiſts might live together in Society, provided they were forced to live contrary to their own Principles? Is it not?

P. It is.

M. But who ſhould force them to live contrary to their own Principles? Or put the Laws ſeverely in Execution? For by Suppoſition, there are none except Atheiſts in the Society. Or does he ſuppoſe that they would chooſe the chief Magiſtrate of a different Perſuaſion, and give him an armed Force ſufficient to oblige them to act contrary to their own Tenets?

P. He does not conſider the Thing in that Light.

M. How doth he conſider it then? Does he ſuppoſe that they would ſo far relinquiſh their own Scheme, as to borrow the Laws of their Neighbours, who own God and Religion?

P. He

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P. He enters not into the Diſcuſſion of any of theſe Particulars.

M. This ſeems to be a notable Piece of Sophiſtry. A Society of Atheiſts could neither get a Syſtem of Laws at firſt; nor could theſe Laws, though once eſtabliſhed, be put in Execution, but in Contradiction to their own Principles.

P. He ſuppoſes the *Ax* and *Gallows* would do all.

M. The Ax and Gallows might head and hang: But he can never ſuppoſe that the Society could have a Right to puniſh, upon their own Principles, ſince all Actions, by theſe, are equally good, or equally bad. And to puniſh on no Principle is Murder. If they could have no Laws, they could have no Puniſhments among them.

P. They might agree to this *by Compact*.

M. Under what Sanction? for an *Oath* has no Signification on the Atheiſt's Principles. Or what Security could Men give, that they would act contrary to their Principles and Belief?

P. The Thing indeed is repugnant in Nature. They could come under no poſſible Obligation of obſerving the Conditions agreed upon, except their own Intereſt: And

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Intereſt would be as great an Obligation for breaking the Contract, as for obſerving it.—This whole Affair, *Matho*, has quite another Aſpect, when conſidered narrowly, than when only looked upon at a Diſtance; nor are we aware how much Society owes to Religion.——

M. How could a Judge determine between contending Parties? Witneſſes could determine nothing: An Oath is as ridiculous in this Caſe, as the former. Men could not ſwear by God, who deny there is a God; nor by their Faith, who believe nothing; nor on their Truth, who deny the *Difference* between Truth and Falſhood.——By what ſort of Engagements could a Man be bound to another for the Performance of any thing? Why ſhould one Man believe another, if it were that other Man's Intereſt to deceive him? Or could Men become more honeſt, becauſe they believed nothing of *God*, *Religion*, and a *future State?*—Muſt the Society always be in a State of War with their Neighbours? For we cannot conceive how they ſhould enter into Treaties, or Alliances of any Sort.——What is ſaid to all this?

P. Not a Word by this Author, whatever may be done by others.

M. Have you any thing to ſay to it?

P. I foreſee what Anſwers you would make; ſo 'tis needleſs to ſpend Time: Only

CLV. You take no Notice of the Obſervation, that Laws are as neceſſary in every Society, as they would be in a Society of Atheiſts.

M. Not ſo neceſſary, I hope. —— But on what Principles are theſe Laws founded? —— Or what ſort of Actions are they deſigned to reſtrain? If a Man *ſteals*, *murders*, *ſwears falſely*, he acts againſt his own Profeſſion; he acts, I ſuppoſe, conſiſtently with Atheiſtical Principles: Is it not ſo?

P. Undoubtedly: For if the ſame Man were an Atheiſt, he could not act better, becauſe he had not good Principles; but might act worſe.

M. Would any Vice in Life ceaſe, if Men became Atheiſts?

P. The ſame irregular Paſſions remaining, Vices muſt then be multiplied: For good Principles are of great Service to Society.

M. All Laws whatever then, for the Support of Society, are made againſt Atheiſtical Principles and Practices. As theſe Principles would tear up Laws by the Roots, all Laws are levelled againſt them. And is it not a fallacious Way of Reaſoning, ſince every where there is a Neceſſity for Laws to bear down the Practices ariſing from Atheiſtical Principles; ſince both the Laws, and the Profeſſion of contrary Principles, can hardly reſtrain theſe Practices; that therefore a Society of Men, having no other Principles, might ſubſiſt by good Laws impartially executed?

P. I do not pretend to defend this Author; yet he has a Salvo for the Difficulties you mention.

M. What is it?

P. Being preſſed with theſe Abſurdities, he retreats to another Defence. He owns Atheiſts could not live according to their own Principles, but contends, that Men do not act according to their Principles.

M. According to what elſe?

P. He avoids being particular; but from comparing ſeveral Places together, it may be gathered, that he means, *Humour*, the *prevailing Mode*, a *particular Paſſion*, *Deſire*

ſire of Praiſe, *Intereſt*; with other Motives of that Kind †.

M. Does he make ſuch Things the Rule of Action?

P. He ſays, Men make them the Rules of their Actions.

M. And thence he infers, that the Atheiſt needs no Laws at all?

P. That is the only Inference that could ſerve his Purpoſe: But he avoids ſuch an open Abſurdity.

† Mr. *Bayle* ſpeaking of an Author who had ſhewn that, on Atheiſtical Principles, Reaſon, civil and natural Obligations, Juſtice and Virtue, were only but Words void of all Senſe, adds —— " Il le prouve fort judi-" cieuſement; mais parce qu'il n'a pas pris garde à une " choſe que je crois avoir demontrée, ſçavoir que les " hommes ne ſuivent pas leur principes, on lui peut " objecter avec raiſon, qu'il n'a rien prové dans cet " endroit-là." §. 181. And again, §. 176. —— " Car s'il eſt vrai que les perſuaſions generales de l'eſprit " ne ſont pas le reſſort de nos actions, & que c'eſt le " temperament, la cûtume, ou quelque paſſion parti-" culiere que nous determinent, il peut y avoir une " diſproportion énorme entre ce que l'on croit, & ce " que l'on fait."—— And in another Place, having reckoned up a great many Actions, which, he ſays, a Society of Atheiſts would obſerve, he aſſigns this Reaſon for it. —— " Soit parce que le deſir d'être loüez les " pouſſeroit a toutes ces belles actions, qui ne ſçauroient " manquer d'avoir l'approbation publique; ſoit parce " que le deſſein de ſe menager des amis & des pro-" tecteurs, en cas de beſoin, les y porteroit."—— §. 172.

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M. This is almoſt above Belief! —— Then there is no need of Laws at all for his Society of Atheiſts: This will do the Buſineſs, Nor are Principles neceſſary in any Society: If this be a good Reaſon why a Nation of Atheiſts ſtood in Need neither of Principles nor Laws, it will be a Reaſon for all Societies whatever. But (not to take Notice that *Humour*, the *prevailing Cuſtom*, *Paſſion*, or *private Intereſt*, are ſtrange Things to truſt the Intereſts of Society to) his Reaſon itſelf ſeems to me as falſe as any thing can be: For whatever a Man acts from, that is his Principle of Action.

P. You are certainly in the right. If he had ſaid, Men do not act according to their *Profeſſion*, there had been but too much Ground for the Obſervation: But a Man never acts contrary to his Principle; the Motive of *Intereſt*, *Praiſe*, &c. is the Principle of ſuch Actions as proceed from them. The Profeſſion of a *Pick-pocket* is Honeſty: But it would be ridiculous to ſuppoſe, that he had an honeſt Principle. Therefore it is of the greateſt Importance to Society, that Men's Principle be juſt and rational. *Principle* is the Source of a thouſand virtuous Actions, the Practice or Omiſſion of which the

the Laws could neither enjoin nor puniſh. Would Men act according to right Principles, the Laws would have little to do. In a Word, there is as great a Difference between one who acts right for fear of the Laws only, and one who acts right from Principle, as between a cunning Rogue, and an honeſt Man. —— But I hope we have now done.

M. Pray don't be ſo impatient.

CLVI. One Particular occurs to me, which I wiſh this Author had conſidered; namely, in what Manner a Society of Atheiſts were to breed up their Children: Whether they were to diſcover to their Children their whole Principles at firſt; that there was neither a God, nor Religion, nor a future State; that whatever they might hear ſaid concerning the Creation of the World, the Government of an *Almighty Being*, Puniſhment of certain Actions in and after Life, *&c.* were but mere Fictions: Or, that Parents might have their Children more obedient and tractable, if they were to educate them in the contrary Belief. For, as far as I can ſee, there are unanſwerable Difficulties, let us make which of the Suppoſitions we pleaſe?

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P. He ſays nothing concerning that Matter.

M. Then he has conſidered his Subject very lamely. One who would ſhew that Atheiſm is conſiſtent with Society, ought to conſider all Things neceſſary to the Continuance of the Society: And there is nothing more eſſential to this, I believe, than the right Education of thoſe who are to conſtitute the Society after we are gone. —— Or perhaps you are amuſing me all this while with an imaginary Author; ſince it is hardly to be ſuppoſed, that any Man would throw out ſuch ſilly ſophiſtical Stuff, and ſo pernicious too in its Conſequences.

P. I am not amuſing you. You cannot converſe long in the World, till you meet with the Book, or perhaps have it recommended to you. And whatever Stuff this may be, or however lamely the Author may have treated his Subject, he hath filled three or four Volumes with it.

M. On what Pretence?

P. On the Diſcuſſion of this remarkable Point, *That Atheiſm is not ſo bad as Superſtition.*

M. The whole Deſign ſeems to be abſurd, and the Handle affected. The Atheiſt is

is the univerſal Parricide —— of God and Man, if I durſt ſo ſay; at leaſt in his Intention. It is not the Tendency of Superſtition to ſubvert Society; if I remember rightly what I have heard concerning the *Ægyptians* and other Nations. But let it be as much worſe than Atheiſm as he pleaſes; it no way alleviates one bad Thing, that another is worſe. It never came into any Man's Head, to run a Parallel between a *Murderer* and an *Incendiary*; or to extenuate the Crime of the firſt, becauſe ſomething worſe might be named.

P. I am of your Opinion: Yet the Author ſays once or twice a ſevere Thing againſt Atheiſm too.

M. With what Deſign?

P. He makes a Merit of it, when he is charged with Partiality. —— But the great Hurt, *Matho*, ariſing from ſuch Performances (which thoſe Authors either do not conſider, or do not regard) is, that though Atheiſtical Principles are aſhamed to ſhew themſelves, Atheiſtical Practice is open and confeſſed: For, as you rightly obſerved, the reſtraining of ſuch Practices is the great and chief Deſign of all Laws: Or what other Name can you give to the *Highway-*

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man, the *Robber*, the *perjured*, the *cunning Oppreſſor*, the *Blaſphemer*, &c. than a practical Atheiſt? How many Crimes, think you, take Birth from a ſecret denying the Juſtice, the Power, or the Knowledge of the Deity? —— In ſhort Atheiſm takes off the Guilt of every Villainy that ever was, or ever can be perpetrated. No Principle elſe offers ſuch an univerſal Invitation to all Wickedneſs. And the endeavour to take off, or leſſen the Horror every Man ought to have of ſuch Principles, is an Attempt a ſober and conſiderate Perſon will never be guilty of.

M. I own the Attempt ſeems as unaccountable to me as Atheiſm itſelf. But if a Nation of Atheiſts could not ſubſiſt, how is it poſſible for them to have ſubſiſted, as thoſe Authors ſay?

P. Cicero obſerves, that a Company of Robbers could not ſubſiſt, but on a Principle of Juſtice among themſelves: We have not now Time to conſider theſe Things farther; only as the Obſervation is unexceptionable, the Application is eaſy; *viz.* That a Nation of Atheiſts could not ſubſiſt, but on Principles contrary to their Belief. As to the real Exiſtence of ſuch Nations, it is remarkable what the Author we have been

ſpeaking

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ſpeaking of ſays, with Reſpect to the Accounts we find in Books of Travels; which is to this Purpoſe: That though we may think it an undoubted Truth, that the *Part* is leſs than the *Whole*, and that Happineſs and Pleaſure are the only Objects of Deſire in the Nature of Things; yet we ſhould be forced to give up theſe two Maxims, however certain we may imagine them, if in any Corner of the Earth the *Whole* were found leſs than the *Part*; or if Men were found, who *loved Miſery*, merely becauſe it was Miſery *.

M. That

* —— "Mais quelque evidentes que puiſſent être "ces deux maximes, il les faudroit abandonner, ſi l'on "decouvroit dans quelque coin de la terre *un tout plus* "*petit que ſa partie*, & quelques hommes qui aimeroient "leur malheur en tant que malheur." Continuation des Penſ. Diverſ. §. 6. To own firſt that theſe Maxims are ſelf-evident, and at the ſame time to ſuppoſe that if a Traveller found them falſe, we ſhould be forced to give them up, is juſt ſaying, if a Traveller found what is impoſſible here to become a Poſſibility on the other Side of the Globe, we muſt give up the Diſtinction between *poſſible* and *impoſſible*. I ſhould rather venture to doubt the Truth of the Relation. It is almoſt equal to this, that in certain Iſlands, three or four hundred Leagues from the *Philippine* Iſles, the Inhabitants are rank Atheiſts, without the leaſt Sign of the Knowledge of a God: And yet they believe the Immortality of the Soul, a Heaven and Hell, and Pleaſures or Torments in an After-

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M. That is to ſay, if an Impoſſibility were found Matter of Fact! we ſhould then

After-State. And then Mr. *Bayle* adds —— " Il ne " faut pas combattre ceci pas des raiſons de metaphy- " ſique. Ces ſont *des faits* contenus dans *une Hiſtoire très curieuſe* publiées depuis peu par un Jeſuite celebre. Ibid. §. 14. One might ask here, how theſe Iſlanders ſhould come by the Notion of the Immortality of the Soul, of Heaven and Hell, *&c.* without the leaſt Idea of Religion? For, " Ils n'avoient pas la moindre idée " de Religion." It is as if he had ſaid, A Man might have the Notion of *a Part*, without having the Notion, that it was the Part of *a Whole*, or of any thing greater. A little after Mr. *Bayle* owns that the Miſſionaries of *China*, who all boaſted to have ſearched the ancient Records of the Country, contradicted each other concerning the Religion of the *Chineſe*; ſome affirming that they acknowledged a God, and others that they were all Atheiſts to *Confucius*'s Time. —— " les uns " avec le Pere le Comte la font orthodoxe, les autres " pretendent que l'Atheiſme a regné dans la *Chine* " juſques à *Confucius*, & que ce grand Philoſophe même " en fût infecté." §. 28. In one Place, Mr. *Bayle*, having ſhewn at great length, that Religion once introduced into the World, can never again be loſt, concludes, that as there are Nations which have no Religion, they muſt have been in that State from their firſt Origin. —— " Comme donc il y a des peuples qui " n'admettent aucune Divinité, il faut conclure qu'ils " ont été dans cet état des leur premiere origine, *&c.*" §. 6. And again, he ſays, according to his Principles, and the Chriſtian Religion, it follows, that there never was a Nation without Religion. —— " Ne me dites " pas qu'un Chrétien ſe peut épargner une partie de la " peine, puiſqu' il ſçait que la Religion eſt auſſi ancienne " que le genre humain: Car même ſelon mes principes, " il s'enſuit de là qu'aucun peuple n'a jamais été ſans " Religion." §. 15.

be

be forced indeed to give up all Truth at once. If the *Whole* were found leſs than the *Part*, all the Demonſtrations of *Euclid* would be good for nothing. However one Thing is certain enough from this ſort of Argument, That if in any Corner of the Earth a Nation of Men were found to ſpring out of the Ground, like Coleworts, they would have neither a Name for, nor any Notion of a Deity.——But ſince an Atheiſt muſt deny that Religion is as ancient in the World as the Race of Men; or, ſince he denies any other Creation than this *Chance-Production*; pray how does he account for the Riſe of Religion at firſt; for its univerſal Spreading; and why Man is thus naturally a *Religious Creature?*

P. It is impoſſible to anſwer all your Queſtions, *Matho*;——Such a Creature as Man, ſo weak, and living in ſuch Dependence, muſt be religious, if he has but the Power of Reflection: Ignorance therefore, and want of rational Improvement will make him ſuperſtitious. As to the firſt Riſe of Religion in the World, the Atheiſt's Account of it in ſhort is this. That ſome prudent and wiſe *Law-Giver* firſt invented the Notion of a God, and the Immortality of the

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the Soul, to frighten Mortals into an Obedience to the Laws, and to make them more virtuous, and better Members of Society, than the Laws could do: With a good deal more to the ſame Purpoſe †.

M. Did one who had never heard of *God*, or the *Soul* before, contrive all this?

P. So the Atheiſt ſuppoſes.

M. At this rate then the Atheiſt owns, that Laws could not bind a Nation of Men, without the Help of Religion.

† See *Sextus Empiricus*, lib. 9. cap. 2. Where he gives the ſeveral Atheiſtical Conjectures concerning the Riſe of Religion. The firſt is, ἔνιοι τοίνυν ἔφασαν τὰς πρώτας τῶν ἀνθρώπων προσάντας, καὶ τὸ συμφέρον τῷ βίῳ σκεψαμένας πάνυ σωφερὰς ὄντας, ἀνεπλάσαι τὴν περί τε τῶν Θεῶν ὑπόνοιαν, καὶ τὴν περὶ τῶν ἐν ᾅδου μυθευομένην δόξαν. The Steps of the Invention were, They firſt made Laws: But theſe being found inſufficient, they contrived the Notion of the Gods, for the more effectual reſtraining of Vice and ſecret Crimes. [where, by the way, we may again ſee, even according to this Original of Laws, that they were firſt made againſt Atheiſtical Practices, and are ſtill neceſſary on the ſame Account.] —— πρῶτον μὲν νόμας ἔθεντο πρὸς τὸ τὰς φανερῶς ἀδικουμένας κολάζεσθαι· μετὰ δὲ τοῦτο, καὶ Θεὰς ἀνέπλασαν ἐπόπτας πάντων τῶν ἀνθρωπίνων ἁμαρτημάτων τε καὶ κατορθωμάτων· ἵνα μηδὲ κρύφα τολμῶσι τινὲς ἀδικεῖν, πεπεισμένοι ὅτι οἱ Θεοὶ. κ. τ. λ. The Account *Critias* (one of the *Athenian* Tyrants) gives, is the ſame. The Place is worth the Peruſal of an attentive Reader.

P. He

P. He owns this to be the Experience of prudent and wiſe *Legiſlators.*

M. It is enough. The Atheiſt is certainly the moſt barbarous Parricide, firſt to allow the indiſpenſible Advantage of Religion to Society, and then to tell the World, it is all a Cheat! ——

P. Here then you again ſee the Neceſſity of believing a future State, in order to our ſubſiſting in this. An infinitely perfect Being, the Author of our Nature could not have ſo conſtituted us, as to make the Belief of a Lie neceſſary to our living together here as rational Creatures. Every thing in the Nature of Man, when it is truly examined, points to the Continuance of our Exiſtence after Death, and ſhews the manifold Relations, which join the preſent to a future State. Theſe Relations ſtretch out to Ages that can never end, and carry on the Exiſtence of rational Beings even to Eternity. The Deſire of Exiſtence (you ſaw) is the Foundation of all our Deſires: A happy or pleaſant Exiſtence is the only conſiſtent Object of Deſire in the Nature of Things: The Deſire of rational Exiſtence and Happineſs, in Oppoſition to ſenſitive Pleaſure, muſt be rational and conſiſtent, by the Terms: This

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Deſire can never ceaſe, more than rational Pleaſure and Happineſs can ever diſguſt and cloy: It cannot be conceived that the Author of our Nature, and of this very Deſire, who is himſelf an infinitely rational Being, ſhould not ſatisfy a rational Deſire; or not ſatisfy it as long as it continues to be, and to be rational; that is, to Eternity.

M. I ſee the Argument as ſtrong as Demonſtration.

P. Theſe are but ſome ſcattered Conſiderations, *Matho*, concerning the Immortality of the Soul of Man. The Nature of our Diſcourſe, and the Shortneſs of our Time, will not ſuffer us to purſue the Subject at juſt Length, and in a proper Method: But theſe Hints, and your own Reflections, as Age ripens, will ſtill farther confirm you in this delightful and comfortable Speculation; which is the main End of all your Studies, all your Application, and in Truth, of all Philoſophy. To contract a Habit of rational Pleaſure, without this Certainty, would only torture you the more.

CLVII. *M.* That would be a melancholly Situation, while we are in Purſuit of Things of an eternal Nature, to be haunted with

with the constant Fears of losing our own Being. The unreflecting State of the brute Animal would be more eligible. Tenth Conference.

P. Hence then it must be an equal Encouragement to consider, that we are engaged in Speculations, the Pleasure and Variety of which will never have an End.

M. It must: Wherefore (to return to our former Subject) I now perceive why, in some Parts of our past Discourse, you put off my Questions concerning the Art in the Works of Nature, which is at present inaccessible to us, either because of its Remoteness or Minuteness; till we should be able to discover something that might shew the Accomplishment of our Desires possible.

P. How doth the Possibility of satisfying this Desire of Knowledge now appear?

M. Since we are carried by a rational Desire to contemplate all the Works of Nature; since we can only get such a Taste of this Pleasure here, as to excite and kindle our Desire; and since all our rational Desires must be satisfied; it follows, that *this Beginning* must be continued, till we at length see the Use, and comprehend the Contrivance of all the Miracles of Power and Skill, thro' the wide material Frame. Our interminable Existence

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Exiſtence ſuits well with ſuch a Deſign, and ſhews every thing conſiſtent. Otherwiſe what a killing Thought muſt it be, to have a View of being turned down with the Ox, while we have the immenſe Proſpect before our Eyes! To bid an everlaſting Adieu to all that which raiſes our Nature above Humanity, being to ſhare the Fate of the Beaſts of the Field! This (let me dare to ſay it) would be the moſt ſtudied Cruelty, the moſt exquiſite Torture of the rational Mind.

P. Conſider what an Immortality of Ignorance would be, forced upon a rational Being thirſting after Knowledge.

M. You ſhew me how wiſely it is ordered, that our Period here ſhould be but ſhort. The Proſpect put off to Eternity would be an eternal pining in Deſpair. This could not be a Work of Kindneſs. Nor can eternal Happineſs conſiſt in Ignorance: That brings it back to ſomething like the Gratification of Senſe. It muſt be intellectual.

P. You are certainly in the right: We cannot have a conſiſtent Notion of immortal Happineſs, unleſs it be ſo conditioned. And as it muſt be *intellectual*, it muſt neceſſarily conſiſt in having the Power and Knowledge, the

the Wiſdom and Goodneſs of the Deity gradually diſcovered to us. This is the only Source of rational and intellectual Pleaſure. The only Source; for there is not another Nature (if I may ſo ſay) which we could apply to, or improve by. To this Purpoſe it is wiſely and wonderfully ordered, that we ſhould begin even by the Methods of Senſe, 'till, having made the intended Advancement, that Method be antiquated, and the Deſign come to be purſued in a ſuperior manner. Theſe Wonders in the material Creation were wrought with this View, to initiate the rational Being, and raiſe it gradually to the Knowledge of *higher and greater Things*. And as was obſerved before, we cannot conceive any other conſiſtent Deſign, why the Author of our Nature at all reared the Frame, if not for the Sake and Improvement of his rational Creatures. It is abſurd to ſuppoſe that he expoſed thoſe Works of Power and Skill to inform no Being; and impious to imagine, that he wrought thus to ſolace or improve himſelf; as if he had not been ſufficiently happy without a material Structure, which he might move and direct various Ways; or, as if he had propoſed to attain at laſt the Perfection

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of Art, by Application and Practice. His Goodneſs only could put him upon the whole Deſign; and the Deſign cannot prove abortive.

M. I am ſatisfied the Deity could not have expoſed thoſe Inſtances of Divine Art for the Inſtruction of no Beings: In that Caſe the Habitation of rational Creatures needed no more Contrivance nor Ornament, than the Retreats of the wild Beaſts. A Convenience for ſenſitive Life had been all that was neceſſary or proper. And if ſuch a World could not be deſigned for Beings of a ſenſitive Nature, it could not be deſigned for the ſenſitive Nature of rational Beings; nor be applicable to their rational Nature in any other Reſpect, than by diſcovering to them the Power and Wiſdom of their Creator.

P. Could our Creator then deſign that we ſhould admire his Power and Wiſdom, only as they were diſplayed on the out-ſides of Things; but reſolved to conceal from us the internal myſteries of Contrivance and Art, leſt we ſhould improve our Nature too much; or admire his Perfections beyond a certain Degree; or come at length to expect more than he could perform?

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M. Theſe are impious Suppoſitions.

P. Or were the external Wonders in Heaven and on the Earth deſigned to catch the Attention, and kindle up in us a rational *Longing*, with a View only to mock and tantalize our Expectations?

M. That would be the low, malicious Pleaſure of a weak Mortal.

P. Or could thoſe Wonders be perceived only by the Methods of Senſe?

M. They could as little be perceived as wrought or effected by the Methods of Senſe. A material Syſtem could no way aid the Soul either to perceive or act: A Syſtem of inert Subſtance limits and confines it in both, and may wholly impede the Exertion of its Powers. This you ſhewed me before. I have no Doubt remaining. The Deity is above Envy: He could not deſign to mock our rational Expectations: His Goodneſs was the only Motive: The Methods of Senſe are incompetent: The Soul, when freed from a dead Subſtance, hath the Limitation taken off: Neither the Subtilty of the Art, nor Remoteneſs of the Object, can be a Let to a pure Spirit: —— But to the Knowledge of what *higher and greater*

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Things were the Wonders in the material Univerſe deſigned to raiſe us?

CLVIII. *P.* And yet Matter, however heightened by Workmanſhip, is (as you yourſelf acknowledged before) the very loweſt of Things; a ſluggiſh and inert Subſtance, utterly deſtitute of all active Power, and capable only of being paſſive. Wherefore beware leſt you imagine, that this dead Subſtance obtains the higheſt Rank in the Works of the Creator. Nothing, it is true, could be better fitted to initiate Beings, whoſe firſt Informations of Things are *from* Senſe, and to train them up in the Elements of Knowledge and Admiration: But the *external Frame*, the *Caſe*, can never be of equal Dignity with the Thing for whoſe ſake it was made, nor an equal Inſtance of Skill and Power.

M. You recall once more to my Thoughts the ſeveral Particulars we ſaw and concluded concerning the Nature of this Subſtance. Unwrought Matter preſents us with the Power of the Deity: But we can turn our Thoughts to no Species of it in the Univerſe, that has not gone through the Hands of the Artificer.

Artificer. —— It is ſo wonderfully made, to ſupport our Bodies, relieve our ſenſitive Appetites, and convey the Notice of external Objects to the Soul, by Means of the Senſes, that by conſidering all the Effects, without looking to the *Cauſe*, or reflecting upon the *End*, Matter is become the Deity of Mankind. —— But I likewiſe ſaw, that the Soul of Man, and of every Animal, is an immaterial Being; and that the different Structure of the Body, in every Species of living Creatures, is fitted to the various Powers and Capacities of this living Principle. Hence it is reaſonable to allow, that the Creator has ſhewn more Art and Power in making this more noble Being; nor can there be leſs Variety in the living, than in the dead Part of the Creation.

P. The Works of the Deity, *Matho*, as we have often ſaid before, conſtitute a certain *Scale*, or Gradation, which ſtill riſes in Dignity. For they are either *purely material*, or *immaterial Subſtance*, joined to an organized Body, or laſtly *pure Spirits*, free from all Contagion of Matter. Since then in the firſt two Parts of the Scale, there is ſuch an amazing Variety of intermediate

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Species, beginning at unwrought Matter, and aſcending to Man; it is altogether incongruous, that in the *third Order* there ſhould be no Gradation nor Variety; but that after we have once got above the Alloy and Depreſſion of a dead Subſtance, we ſhould then have riſen to the Supreme Being.

M. It is certainly incongruous that all above the Confines of Matter ſhould be a mighty Blank.

P. The Series of immaterial Beings begins with the very loweſt Animals; that is, it borders on the vegetable Kingdom, and riſes by innumerable Steps to Man: Now what is there between *Man* and the *Deity*? —— Nothing?

M. The third Order ſeems to be entirely wanting, and the Scale broke off in the Middle, unleſs there ſtill remains a proportional Gradation among *pure Spirits*, ſtill riſing in Degrees of Perfection.

P. Since then, there are none of the Works of God, but what ſerve for the Advancement of the rational Nature; none of them ſecluded or hid from the rational Spectator; what Wonders of Power and Wiſdom,

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Wiſdom, do you think, muſt ſtill remain, after we have are above the paſſive Nature of a dead Subſtance? How much a greater Inſtance of Power is it, to have beſtowed *Power itſelf*, and various Degrees of it too, upon other Beings, than to have exerted his own Power only on this paſſive Subject?

M. This I in ſome Meaſure conceive, if I compare *ſelf-moving Engines* (as they are ſuppoſed) with any common Inſtrument, which requires the conſtant Application of the Hand. Though I am aware, that *Clock-Work* hath, properly ſpeaking, no Power in itſelf. ——

P. Or could the Deity have beſtowed Power and Agency on Living Beings, only as they were clogged with Syſtems of dead Matter?

M. Ah! Do not aſk a Queſtion ſo abſurd! As if Matter could contribute any thing, by confining, or obſtructing the Powers of a living Being!

P. Or could He not have imparted to them Powers above thoſe of the human Soul, without encroaching on his own Omnipotence?

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M. It is too much, *Philon*; I ſee the immaterial, the ſpiritual, the living Part of the Creation, may riſe in Degrees of Power above our Conceptions; yet without being able to approach the boundleſs Perfections, and ſelf-exiſtent Nature of the Creator.

P. If therefore there muſt be an infinite Diſtance between the higheſt created Nature, and the neceſſary Perfections of the Deity, the Knowledge of created Beings, or concerning created Things, muſt fall infinitely ſhort of the Knowledge in the *Divine Mind*. The Connexion of eternal Ideas, which have no Relation to the Exiſtence of any Thing, except the Mind, whoſe Ideas they are, are many ways, infinite ways, infinite. We may ſtill be advancing in the Perfection of our Nature, and ſtill muſt be at an infinite Diſtance from the *neceſſarily exiſting Being*.

M. I ſee that *Neceſſity* of *Perfection* muſt infinitely prevent all poſſible Improvement of Perfection.

P. You expreſs the Diſproportion, *Matho*, juſtly: As an endleſs Addition of Minutes could never conſtitute Eternity, nor make the future Proſpect leſs; ſo it is between

between immortal Beings, ſtill advancing in Perfection, and the Deity neceſſarily perfect. And in this conſiſts the eternal Happineſs of rational Beings, endleſly to acquire new Acceſſions of Perfection and Happineſs, with an infinite Proſpect ſtill before them. Thus the Soul muſt flouriſh in the Adoration and Love of its *Maker*, through Ages that cannot end, and in the Fellowſhip of happy Spirits paſt numbering.

M. Nor does the Certainty of this Proſpect leſs conſtitute our preſent Happineſs; ſince theſe Reaſons cannot fail, or yield, in Sickneſs, Danger, or Death itſelf.

And now, *Philon*, I ſhall put an end to my Queſtions, and the Trouble I have given you; nor ſhall I attempt to expreſs in Words the Senſe I have of your Friendſhip: But while I remember the noble Truths you have ſhewn me, and the Dignity of the human Soul, I cannot forget the Man who firſt led me through theſe pleaſing Speculations.

P. This is too much, *Matho*, to your Friend. Were it true, that I had been ſo ſerviceable to you as you ſpeak of, my Pleaſure

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Pleaſure muſt be at leaſt equal to yours. But you owe the greateſt Part of theſe Diſcoveries to your own *Genius*, the Happineſs of which I have often admired in the Courſe of our Conferences; for you diſcovered the Reaſons of Things yourſelf, and generally prevented what I had to ſay.

ANNOTA-

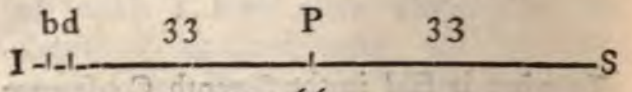
ANNOTATION

To what is ſaid in the Seventh Conference above, concerning the Point of equal Attraction between the Sun and any of the Planets; or *that Point*, where if a Body were placed, it ſhould gravitate neither to the Sun, nor to the Planet.

AS the Method propoſed in the Note at the End of the *Latin* Pamphlet; for enquiring into the Sun's Parallax, and approaching, if poſſible, nearer the Truth, has not, I humbly think, been ſufficiently conſidered; I beg Leave to tranſlate the Note here, and make it a little plainer, that what is propoſed may be ſeen with the leſs Trouble: Hoping no one will be offended, ſince I do it with no View to *contradict*, or *find Fault*, but only for the Sake of what I take to be the Truth.

The Method of finding out the Point of equal Attraction between the Sun and any Planet, the Quantity of whoſe Matter is known with Reſpect to that of the Sun, will

will eaſily appear from an Example. Let the Line IS repreſent the Diſtance between *Jupiter* (for Inſtance) and the Sun.



Upon the Suppoſition that the Sun's Diſtance from the Earth is about 21000 of the Earth's Semi-diameters, the Quantity of Matter in the Sun is to that in *Jupiter* nearly as 1089 to 1; which is eaſily diſcovered from what is ſhewn in N°. 131 above. The Square Root of the Number 1089 is 33. Now at an equal Diſtance from both Bodies, or at the middle Diſtance P between their Centers, their attractive Forces are as their Quantities of Matter, 1089 and 1: That is, the Sun's Attraction is there 1089 Times ſtronger than *Jupiter*'s. Let I b be $\frac{1}{33}$ part of I P, (or $\frac{1}{66}$ Part of the whole Diſtance I S;) and *Jupiter*'s Attraction at b will be 1089 Times greater than it is at P; for it is inverſely as the Squares of the two Diſtances I b and I P. Therefore *Jupiter*'s attractive Force at b, and the Sun's at P muſt be equal. Then ſince both Forces decreaſe

creaſe as the Squares of the Diſtances increaſe, they muſt come to be equal again, or balance each other, at ſome common Point between b and P. Let that Point be d. And ſince *Jupiter*'s Force at b, is to his Force at d, as the Sun's Force at P, is to his Force at d; (for as the Antecedents are equal, ſo are the Conſequents;) the Squares proportional to theſe Forces muſt alſo be proportional; that is, I d Square is to I b Square as S d Square is to S P Square; and, by Inverſion, I b ſq. : I d ſq. :: SP ſq. : Sd ſq. And (by *Eucl.* VI. 22.) Ib : Id :: SP : Sd. Hence, making bd=x, it will be, $1 : 1+x :: 33 : 65-x$ or $33-33x = 65-x$. Whence bd or $x = \frac{32}{34} = \frac{16}{17}$. Thus Id, or $1+x$ is equal to $\frac{1}{66}$ Part of the whole Diſtance between the two Bodies, and $\frac{16}{17}$ of $\frac{1}{66}$ Part: But it cannot be equal to $\frac{2}{66}$ Parts, or $\frac{1}{33}$ Part of the whole Diſtance. For if Id were double Ib, Sd would be double SP; that is, d would coincide with I, which is repugnant.

Hence we may form this general Rule concerning the Point, where the attractive Force of a Planet is equal to the attractive Force of the Sun, *viz.* That it is more remote from the Planet than that Part of

the Diſtance between the Sun and it, which is expreſſed by a Fraction, whoſe Numerator is unit, or the Quantity of Matter in the Planet; and the Denominator is twice the Square Root of the Quantity of Matter in the Sun: But it can never come to be equal to two ſuch Parts.

From this we may eaſily ſee that the Point of equal Attraction between the Sun and this Planet falls a great Way without the Orbit of his utmoſt Satellite. If the Earth's Diſtance from the Sun be 21000 of its own Semi-diameters, *Jupiter*'s Diſtance from him is about 5264 of *his* Diameters. And ſuppoſing the *Point of equal Attraction* between him and the Sun $\frac{1}{10}$, of this Diſtance, that comes to about 159 of his Diameters: Whereas his outermoſt Satellite is diſtant from his Center only 12 $\frac{2}{3}$ Diameters. All his Satellites therefore lie far within the Limits of their Primary's ſtronger Attraction; ſo that they muſt have been removed to a vaſt Diſtance from him, if they had revolved about the Sun ſeparately, as primary Planets; as was obſerved above (N°. 116.) The ſame Way it may be found that the innermoſt of *Saturn*'s Moons muſt have revolved at a greater Diſtance

ſtance from his Center, than 84 Diameters of his Ring, to have been without the Limits of his prevalent attractive Force; whereas the outermoſt of them is not above 12 of theſe Diameters removed from his Center. Which ſhews us clearly that the Bounds of the Solar Syſtem muſt have been greatly enlarged, had the 9 Satellites of thoſe two Planets revolved immediately about the Sun as primary Planets. *Saturn*'s Satellites, for Inſtance, muſt have been removed, not only without the Limit of equal Attraction between the Sun and him, but the loweſt of them muſt have revolved at a far greater Diſtance from *Jupiter*, than *Saturn* himſelf now revolves: Since if *Jupiter* diſturbs them at preſent, notwithſtanding the attractive Force of their Primary, he muſt have drawn them quite down then, when nothing but their centrifugal Force kept them in their Orbits.

This Calculation proceeds on the common Suppoſition, that the Sun's *Parallax* (or the Angle which the Semi-diameter of the Earth ſubtends at the Sun) is 10 Seconds; and therefore that the Diſtance of the Earth from the Sun is about 21000 of its own Semi-diameters. But when I endeavoured

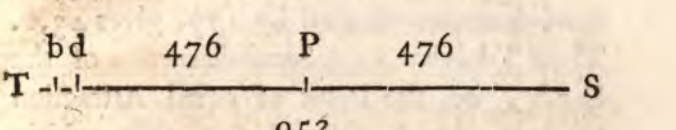
deavoured to apply the ſame Argument and Calculation to our Moon, in order to diſcover how far ſhe was within the Limit of equal Attraction between the Sun and Earth, I was ſurprized to find, that, on this Suppoſition, ſhe muſt revolve a great Way without that Limit. This made me ſuſpect ſomething not commonly attended to, which will prove to us (I ſtill humbly think) that the Diſtance of the Sun cannot be near ſo great. However, I ſhall give the Calculation itſelf, that it may be examined.

If the Sun's Parallax be 10″, or rather 9″ 54‴, his mean Diſtance from the Earth will be 20797,5 of its Semi-diameters; and the Quantities of Matter in the Sun and Earth will then be as 277000 and 1; by what is ſaid above, N°. 131. For ſince the Moon's periodical Time is 655 Hours 43 Minutes, or 655,716 Hours, the Square of it will be 429963,472656: And the Square of her periodical Time, if ſhe revolved at the ſame Diſtance from the Center of the Earth as *Venus* does from the Center of the Sun, would be 66010844672 78. *Venus*'s periodical Time is 5393 Hours; the Square of which is

29084449

29084449. And the Quantity of Matter in the Sun will be to the Quantity of Matter in the Earth inverſely as the Squares of the periodical Times of two Bodies revolving about them at equal Diſtances: That is, as 660108446727 8 to 29084449, or as 277000 to 1. This I have ſet down, that any ingenious Perſon, tho' a Stranger to theſe Things, may ſatisfy himſelf, by going through the whole Calculation, if he has a Mind.

The Square Root of 277000 is 476, neglecting the decimal Parts. Let the Line



TS repreſent the Diſtance between the Centers of the Earth and Sun. At the middle Point P between their Centers the Sun's Attraction is 277000 Times greater than the Earth's. Let Tb be $\frac{1}{476}$ Part of TP, or $\frac{1}{952}$ Part of the whole Diſtance TS, as before; and the Earth's Attraction at b will be 277000 Times greater than at P; or it will be equal to the Sun's Attraction at P, for the Reaſon aſſigned above. Let d be the com-

mon Point between b and P, where they will again be equal; and then, as in the former Example, Tb : Td :: SP : S*d*, or (making bd = x) it will be, 1 : 1 + x :: 476 : 951 — x. Hence 476 + 476 x = 951 — x; and $x = \frac{475}{477}$. Therefore Tb + bd, or 1 + x is equal to $\frac{1}{952}$ Part of the whole Diſtance TS + $\frac{475}{477}$ of $\frac{1}{952}$ Part of it; but cannot be equal to $\frac{2}{952}$ Parts, or $\frac{1}{476}$ Part of it.

Since Td, or 1 + x is equal to 1 $\frac{475}{477}$ (=1,9958) of TS, it is $\frac{1}{477}$ Part of it; for $1,\frac{952}{9958}$ is = 477. And 20797,5 Semi-diameters divided by 477, gives 43,6. Thus Td is = 43,6 Semi-diameters of the Earth; or the Point of equal Attraction between the Earth and Sun falls within 43,6 Semi-diameters of the Earth's Center.

The Moon revolves at 60, ſometimes at 63 Semi-diameters of the Earth from its Center; in which Caſe it ſtill appears to me that in every Conjunction ſhe would deſert the Earth, carried off by the prevalent Force of the Sun; at leaſt, if the Reaſoning in the Seventh Conference above be juſt. For then we muſt ſuppoſe, either that ſhe is carried round the Earth contrary to the common

common Law of Gravity, and on other Conditions than the Satellites of *Jupiter* and *Saturn* are carried round their Primaries; or elſe that both the Quantity of Matter in the Sun, and his Diſtance from the Earth, muſt be different from thoſe laſt aſſigned. Let us try therefore what his Diſtance muſt be, that this Limit of equal Attraction between him and the Earth may fall without the Orbit of the Moon.

It has been obſerved before (N°. 99.) that the greater the Quantity of Matter in the Sun is, or the greater the Diſtance between him and the Earth is ſuppoſed to be, the nearer the Limit where they attract equally will approach to the Earth. Thus if we make his Parallax 6″, and therefore his Diſtance from us 34377 Semi-diameters of the Earth, according to the celebrated Mr. *De la Hire*, by proceeding as before, the Quantity of Matter in him will be to the Matter in the Earth, as 1024820 to 1. The Square Root of 1024820 is 1012, and $\frac{34377}{1012}=34$. Whence the Limit of equal Attraction then between the Sun and Earth will be but about 34 Semi-diameters of the Earth from its Center. On this Suppoſition therefore, the

Force of the Earth to retain the Moon in her Orbit would be little more than a 4th Part of the Sun's Force to draw her from it.

If we make the Sun's Parallax 12″, the double of the laſt, his Diſtance from us will be one half of the former, or 17188 Semi-diameters of the Earth; and the Quantity of Matter in him will be as 128102, the Matter in the Earth being ſtill as unity. The Square Root of 128102 is 357; and $\frac{17188}{357} = 48$. The Point of equal Attraction therefore ſhould be but 48 Semi-diameters of the Earth from its Center; and its Force at 60, or 63 Semi-diameters Diſtance, would ſtill be much too weak to keep the Moon in her Orbit.

If the Parallax ſhould be ſuppoſed 20″, or the Sun's Diſtance from the Earth 10000 of its Semi-diameters; the Quantities of Matter in the Sun and Earth will be as 25230 and 1. The Square Root of 25230 is 158; and the Diſtance of the Limit of equal Attraction will be $\frac{10000}{158} =$ 63 Semi-diameters of the Earth from its Center. Here the Sun and Earth's Forces would be but equal in the Moon's *Apogæum*; whence ſtill there is nothing, no

Cauſe

Cauſe to make her mount up again towards the Earth's Orbit, after her Conjunction.

Laſtly, Let us ſuppoſe that the Diſtance of the Earth from the Sun is only 8000 of its own Semi-diameters; or that the parallactick Angle is 26″; and the Quantities of Matter in the Sun and Earth then will be as 12917,8 and 1. Here (the Square Root of 12917,8 being 113,6) the whole Diſtance TS will be expreſſed by double that Root, or 227,2; and Td, or 1+x is equal to $1\frac{112,6}{114,6} = 1,982$ of the whole Diſtance. Wherefore $\frac{227,2}{1,982} = 114,6$; and $\frac{8000}{114,6} = 69,8$ Semi-diameters of the Earth. Here perhaps we may ſtop, having got the Point of equal Attraction between the Sun and Earth, without the Orbit of the Moon: But ſooner I think we cannot ſtop. For when the Sun is at this Diſtance from us, the Force of the Earth upon the Moon at her middle Diſtance, is to the Force of the Sun upon her, only as 1,334 to 1: And in the *Apogæum*, it is but as 1,227 to 1; which cannot be too much, that the Earth may have the Command of its own Satellite. We will rather, I believe, think it too little, if we conſider an Obſervation made by the

the learned Doctor *Halley*, which has a Relation to this Matter.

It hath been obſerved before that, if the Diſtance of the Earth from the Sun be 21000 of its own Semi-diameters, its mean Motion will be at the Rate of a 1000 *Engliſh* Miles in a Minute. Or, if its Diſtance were (according to M. *De la Hire)* 34377 ſuch Semi-diameters, it muſt move at the Rate of 1635 Miles in a Minute. And yet the learned Gentleman juſt now mentioned thinks it great that it ſhould move at the Rate of 210 Miles in a Minute. In his Obſervation of *Mercury* in the Sun at St. *Helena*, 1677, he ſays that the annual Motion of the Earth is ſo exceeding ſwift, as far to exceed that of a Bullet ſhot out of a Cannon, and to be after the Rate of 3 *Engliſh* Miles and an half in a Second, which is 210 Miles in a Minute, or 12600 Miles in an Hour *. Here it may not be amiſs to conſider what the Earth's Diſtance from the Sun would be, according to this Velocity of Motion in a Minute.

* See Doctor *Harris's Lexicon Technicum*, in the Word *Earth*, Vol. I.

The

The Minutes in a Year are 525969. The Miles then in the Earth's annual Orbit will be 210×525969, or 1104543490 *Engliſh* Miles. The Diameter of the Earth itſelf is, according to Mr. *Norwood*'s Menſuration, 7967,7 ſuch Miles. But 1104543490 divided by 7967,7 gives us 13862,6. That is, the Miles in the whole annual Orbit, divided by the Miles in the Earth's own Diameter, gives us the Number of Diameters in the whole Circumference of the Orbit, *viz.* 13862,6; if its Motion be 210 Miles in a Minute. And there will be juſt as many Semi-diameters of the Earth, in half the Circumference of the Orbit. —— The Proportion between the Semi-circle and Radius, is that of 314159 to 100000. Therefore in the preſent Caſe it will be, as 314159 to 100000; ſo half the Circumference of the Earth's annual Orbit expreſſed in Semi-diameters of the Earth itſelf, *viz.* 13863, to 4412,7, the Radius of the Orbit expreſſed in the ſame Semi-diameters of the Earth. —— Thus, if 210 Miles be the Earth's annual Motion in a Minute, its mean Diſtance from the Sun will not be above 4413 of its own Semi-diameters.

This will ſurpriſe thoſe who have been accuſtomed to think of 20000 or 30000 Semi-diameters Diſtance; and yet any ingenious Perſon, how little ſoever ſkilled in theſe Affairs, may try this eaſy Calculation for his own Satisfaction. As 4413 is a great deal leſs than 8000 Semi-diameters, this leſſer Diſtance will throw the Point of equal Attraction between the Sun and Earth ſtill much farther from the Center of the Earth, than 69 or 70 Semi-diameters; and therefore ſtill farther without the Orbit of the Moon: Which, if we reflect how far the Satellites of *Jupiter* and *Saturn* lie within this *Limit* between the Sun and their Primaries, is not at all improbable. For though we ſhould allow (as is but reaſonable) that it is ſcarcely poſſible to make ſuch Obſervations with the laſt Degree of Exactneſs, yet it is hard to ſuppoſe that this Great Man aſſigned to the Earth little more than the fifth Part of its real Velocity.

If the Sun's Diſtance from the Earth be 8000 Semi-diameters, (and it is far more probable that it ſhould be leſs than greater) the Earth's Motion in a Minute will be 381 Miles. If their Diſtance ſhould be 7000 Semi-diameters of the Earth; which Dr.

Keill ſays is the only Thing that is certain, from the ſeveral Methods of obſerving the Parallax; the Motion of the Earth will be about 333 $\frac{1}{8}$ Miles in a Minute. So that Doctor *Halley*'s Obſervation cannot be ſo wide as the common Parallax of 10 Seconds would make it. But theſe Things I leave to the Conſideration of better Judges.

There were ſome other Particulars in the *Latin* Note, concerning the Weight of Bodies on the Surface of the Sun, his Diameter and Denſity, on the Suppoſition that his Diſtance from us was 8000 Semi-diameters of the Earth; which I omit, ſince it ſeems plain that his Diſtance is not ſo great. I ſhall only take Notice of one Thing mentioned there, *viz.* That whatever the Sun's Diſtance from the Earth may be, his attractive Force on the Earth will be ſuch as to hinder it with the Moon to roll round their common Center of Gravity. The only Thing that could make the Earth revolve about this Center muſt be the attractive Force of the Moon upon it; which Force muſt ſurely have this Effect, if no other Force intervened; as was obſerved in N°. 96. in the Seventh Conference. But if a Force many Times ſtronger

than this detains the Earth, it cannot yield to a weaker in Oppoſition to ſuch ſtronger Force. This will be plain if we conſider, that the Earth in revolving about this Center muſt ſometimes riſe to an abſolutely greater Diſtance from the Sun, and then fall down through a certain Space nearer him: For (as was obſerved N°. 97.) it is the common Center of Gravity between it and the Moon, that keeps always at an equal Diſtance from him. And if the Earth could not make the Moon riſe in Oppoſition to the Sun's ſtronger Action upon her, much leſs could the Moon make the Earth riſe in Oppoſition to the ſame Action. As in that Caſe we conſidered the Point of equal Attraction between the Sun and the Earth, ſo in this we muſt conſider the Point of equal Attraction between the Sun and the Moon. Which Point, if the Earth's Diſtance from the Sun be 21000 of its own Semi-diameters, is hardly 7 ſuch Semi-diameters from the Center of the Moon; and if the Diſtance be but 8000 Semi-diameters, the Point of equal Attraction between the Sun and Moon is not yet above 11 ſuch Semi-diameters from her Center. On the former Suppoſition the Sun's Force

upon the Earth is to the Moon's Force upon it as 76 to 1; and on the latter, as 29 to 1. And if a Force as 29 were overcome by 1, certainly the Force as 28 would be overcome by nothing. There is no explaining, by any *Example* or *Simile*, (as has been endeavoured) how the Earth and Moon may revolve about their common Center of Gravity, in a mechanical manner, unleſs each of them attracted the other more than the Sun does: That is, unleſs each of them revolved within the Limit of equal Attraction between the other and the Sun. And even then their Motion about this imaginary Point would be any Thing rather than *mechanical*. I deſire any one ſeriouſly to read N°. 97. above, and then to declare whether he thinks that ſuch a Motion, as this is there ſhewn to be, could either be performed or explained mechanically.

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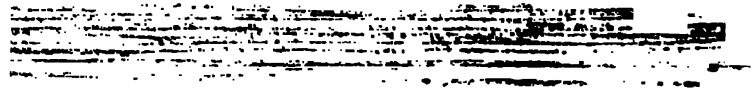

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